F42630-02-RAAAC, Performance Specification (that will be produced as AF Dwg 200310516) Dated 12 Mar 2003.

INTERESTED PARTIES ARE REQUESTED TO **RESPOND NLT 28 MARCH 2003**!

T-38

WHEEL AND BRAKE

PERFORMANCE SPECIFICATION

12 MAR 2003

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APPROVED SOURCES OF SUPPLY

Spec Number	Supplier's Part Number	FSCM Number	Supplier's Name and Address	Final Approval Date

PARTS LIST

Spec Number	Supplier Part Number	Description	Max. Weight (LBS.)

ACTIVE RECORD SHEET

		Added Sheets				Added Sheets	
Sheet Number	Rev. Sym.	Sheet Number	Rev. Sym.	Sheet Number	Rev. Sym.	Sheet Number	Rev. Sym.

REVISIONS

Rev. Sym.	Description	Approval/Date

1. SCOPE

1.1 *Purpose*

This document establishes performance requirements for the design, testing, manufacture, and acceptance of a T-38 main landing gear wheel and brake. The wheel and brake assembly shall be designed and optimized for non-antiskid controlled operation. Consistent torque performance for a given pressure over all operating conditions is desired to minimize the possibility of a tire skid.

1.2 *Order of Precedence*

When the requirements of the contract, the performance specification or applicable subsidiary specifications are in conflict, the following shall apply:

a. Contract. The contract shall have precedence over any other document.
b. Aircraft Specification. The general specification for design and construction of aircraft weapon systems shall be addressed to the procuring activity when in conflict with the procurement specification.
c. Performance Specification. The wheel and brake performance specification shall have precedence over all applicable subsidiary specifications.
d. Reference Documents. Any Document referenced in this specification shall have precedence over all documents referenced therein.

1.3 *Improvements and Deviations*

Minimum size and weight, simplicity of operation, ease of maintenance, and an improvement in the performance and reliability of the specific functions beyond the requirements of this specification are objectives, which shall be considered. Where it appears that a substantial reduction in size and weight or improvement in design performance shall result from deviations to the performance specification, a written request for approval shall be submitted to the procuring activity for consideration. Each request shall be accompanied by complete supporting information. Deviations to the performance specification shall not be made without written authorization from the procuring activity. Options requiring deviations to this specification cannot be made as part of any competitive proposal. The evaluating team cannot approve or disapprove these requests for deviation.

1.4 *Approval*

The components of the wheel and brake assembly shall meet the requirements specified herein at the guaranteed maximum weight of 63 pounds. Workmanship shall be in accordance with high-grade aircraft practice and of quality to ensure safety, proper operation and service life. Compliance with the performance specification shall consist of a written approval letter from the military engineering directorate responsible for the equipment (procuring activity).

2. REFERENCES

Table-1 (Specifications and Standards) identifies specifications and standards that are referenced in this document, by subject and last known active specification. In the event that a referenced specification or standard contradicts this document, this document shall control the requirement. If a referenced specification or standard becomes cancelled or deactivated, or if an alternative specification or standard is desired, the supplier shall seek replacement authorization from the procuring activity. The supplier shall provide a summary of differences between the specification referenced in this document and the proposed alternative specification. Proposals for alternative specifications will be evaluated in accordance with source selection criteria.

3. REQUIREMENTS

3.1 Interface Definition

3.1.1 Tire

The main gear wheel shall interface with a 20X4.4 14PR bias and radial tire. The tire to wheel interface shall conform to approved specification (ref.: Tires, Aircraft Pneumatic).

3.1.2 MLG Piston Assembly

The wheel and brake shall interface with the main gear axles as shown in Figure – 1A (Wheel and Brake Envelope) Figure – 1B (Brake Flange Interface), Figure 1-C (Jack Pad), and Northrup Drawing 3-40608.

3.1.3 Hydraulic System

Brakes shall be designed for use with hydraulic operating systems in accordance with approved specification (ref.: Systems, Brake (design)), compatible with the aircraft system (ref: Ronson 94641, Dwg 6U6033, Corresponding performance specification 6033 S). The brake shall be designed to operate with hydraulic fluid in accordance with approved specification (ref.: Hydraulic Fluid). The maximum hydraulic pressure available to the brake shall be 625 psig. The brake shall be capable of operation at 5 psi back pressure (no piston travel at pressures equal to or less than 5 psi). The wheel and brake assembly shall be designed and optimized for non-antiskid controlled operation.

3.1.4 Hubcap

The wheel shall include provisions for future attachment of a hubcap.

3.1.5 Envelope

The wheel and brake shall fit within the envelope described in Figure – 1A (Wheel and Brake Envelope).

3.2 Drawings

3.2.1 Design Proposal Drawings

Design proposal drawings prepared by the wheel and brake supplier shall include the following:

a. Reference to the applicable specification.

b. Two-view and cross-sectional drawings including definition of the rim flange, brake and wheel mounting, hydraulic installation data, and envelope definition.

c. Material, principal manufacturing processes, and finishes definition for all major components.

d. Wheel static and dynamic loading conditions, brake energy definitions, separate and combined maximum and average weights for the wheel and brake assemblies.

e. Brake design parameters including:
   (1) Heatsink new and worn mass
   (2) Drawing definition of heat sink components
   (3) Swept area
   (4) Mean radius
   (5) Piston area
   (6) Thermal fuse plug rated release temperature and tolerance
   (7) Piston housing fluid volume

f. Hydraulic pressure-volume curve for a new and worn heatsink at 70°F that indicates:
   (1) Pressure to begin brake piston movement
   (2) Pressure to cause disk contact
   (3) Brake release pressure
   (4) Maximum system pressure

g. Other technical information necessary to communicate the design.

3.2.2 Interface Drawing

Drawings shall be prepared for interface components of the approved assembly. The drawings shall be suitable for preparation of a wheel, brake or wheel-brake assembly interface design drawing and specification.

3.3 Selection of Materials, Parts and Processes

The materials, parts, and processes used shall be selected to accomplish the designated performance requirements. The supplier shall be responsible for selection of materials, parts and processes that provide reliable performance, with regard to the interface and all possible operating environments. All materials and parts shall be maintainable by processes that are available from at least two commercial sources.

The supplier may propose alternative specifications and standards for materials, parts and processes (reference paragraph 2).

3.3.1 Materials

All parts of the assembly shall be made of corrosion resistant material or shall be suitably protected against corrosion and oxidation internally and externally during normal service life. Service experience of similar designs is required to illustrate service life durability. The use of dissimilar metals in contact with each other shall be avoided. When this is not practical, they shall be suitably protected against galvanic corrosion. Dissimilar metals are defined in dissimilar metals standard (ref.: Metals, Dissimilar) or the ASM metals handbook. Carbon composites shall be considered as graphite for dissimilar metal purposes.

3.3.1.1 Metals

3.3.1.1.1 Aluminum

3.3.1.1.1.1 Aluminum Castings

Aluminum alloy castings shall conform to approved specification (ref.: Castings, Aluminum). Permanent mold castings shall conform to approved specification (ref.: Casting, Permanent Mold). The minimum ultimate tensile strength of the test specimens cut from castings, in addition to referenced specification requirements and unless otherwise specified, shall be not less than 50% of the values for separately cast test bars. The ultimate tensile strength of test bars cut from critical areas of wheel castings shall be not less than 75% of the values for separately cast test bars.

3.3.1.1.1.2 Aluminum Forgings

Aluminum alloy forgings shall conform to approved specification (ref.: Forging, Aluminum).

3.3.1.1.1.3 Shot Peen Aluminum

Where practical, all high strength aluminum parts shall be saturation shot peened in accordance with approved specification (ref.: Shot Peen, Metals) with 200% coverage.

3.3.1.1.2 Steels

Aircraft quality steels shall be used as required.

3.3.1.1.2.1 Steel Selection

The following shall apply in the selection and processing of steels:

a. Reserved
b. Consumable electrode vacuum melted steel shall be used for parts made from heat-treated alloy steel with ultimate tensile strengths of 220 KSI and above. The variation in ultimate tensile strength for the parts shall not exceed -0/+20 KSI. The use of steel heat-treated in excess of 220 KSI shall be subject to specific approval of the procuring activity (reference Paragraph 2).
c. Steel forgings shall comply with approved specification (ref.: Forgings, Steel).
d. Preference shall be given, in the selection of carbon and low alloy steels, to compositions having the least hardenability that shall ensure through hardening of the part concerned.
e. Steel parts shall be heat treated in accordance with approved specification (ref.: Heat Treatment, Steel).
f. Composites shall be selected so that heat treatment to the required strength and service temperatures shall preclude temper-embrittlement.
g. Steels whose mechanical properties are developed by cold deformation shall be selected so that the recovery temperature shall be at least 50°F above the expected maximum operating temperature range.
h. Critical parts shall be designed and processed so as to result in no decarburization of highly stressed areas. Elsewhere, decarburization shall be avoided or eliminated wherever practical and, where not practical, shall be compensated by appropriate reductions in design fatigue life strength. Parts heat-treated above 180 KSI strength shall require procuring activity approval (reference Paragraph 2).
i. The mechanical drilling of holes in martensitic steels after hardening to strength levels of 180 KSI and above shall be avoided whenever practical. When drilling is performed on high strength alloy steel parts heat treated to 180 KSI and above the final hole sizing shall be performed in accordance with procedures approved by the procuring activity.
j. Any necessary straightening of parts after heat treatment to strength levels of 180 KSI and above shall be accomplished at the tempering temperature, +0/-50°F, or the parts shall receive a stress-relieving treatment at this temperature immediately after straightening. Parts shall be inspected for cracks after straightening.
k. All high strength steel fittings heat treated to 220 KSI and above shall be saturation shot peened with 200% coverage.

3.3.1.1.2.2 Corrosion Resistant Steels (CRES) Limitations

The following limitations shall apply in the selection and application of corrosion resistant steels:

a. Unstabilized austenitic steels shall not be fusion welded.
b. Precipitation hardening semi-austenitic grades shall not be used in applications that require extended exposure to temperatures in the 750°F – 900°F range.
c. Types 416, 431 or 19-9DL stainless steel shall not be used.
d. Precipitation hardening stainless steels shall be aged at temperatures not less than 1000°F in all applications. Exception is made for castings that may be aged at 935°F +/-15°F and fasteners, which may be used in the H950 condition. Exception may also be made for springs of 17-7 PH CRES with a CH 900 temper using a 900°F aging temperature.

3.3.1.1.3 Titanium

3.3.1.1.3.1 Titanium Forgings

Titanium forgings shall comply with approved specification (ref.: Forging, Titanium).

3.3.1.1.3.2 Titanium Sheet and Plate

Titanium sheet and plate shall comply with approved specification (ref.: Forging, Plate).

3.3.1.1.3.3 Titanium Alloys

Titanium and titanium base alloys may be used in applications where their use is justified in terms of weight savings, improved performance, improved serviceability, and where adequacy of manufacturing methods can be demonstrated. All applications shall use the annealed rather than the solution treated or solution treated and aged material condition. All titanium-machined parts shall be saturation shot peened with 200% coverage in compliance with approved specification (ref.: Shot Peen, Metals).

3.3.1.2 Composites

Structural carbon-carbon composites. When carbon-carbon composites are used, metals in contact with the carbon material (graphite) shall be considered dissimilar metals. Metals prone to galvanic attack in contact with graphite composite shall not be used. All carbon heatsink material shall be traceable by batch or lot number to the brake serial number level. The supplier shall develop material consistency tests for procuring activity approval which shall be conducted on samples extracted directly from the production process and submitted as required for the Acceptance Tests. The material property tests established by the supplier shall be conducted on qualification vintage material in order to define the baseline properties for quality control of follow-on brake heatsinks. Similar supplier established material property tests shall be conducted on a steel heatsink if this material is selected for the brake friction material. The supplier shall control sub-suppliers in the procedures, maintaining the quality and performance of the manufactured product.

3.3.1.3 Non-Specification Material

For materials which no federal, military or industry specification exists, the supplier shall be required to develop specifications covering technical requirements, test methods, and acceptance criteria. These specifications shall be available for review and acceptance by the procuring activity at the supplier's facility.

3.3.1.4 Restricted Material

3.3.1.4.1 Beryllium

Beryllium shall not be used in brake heatsink lining material. Copper-Beryllium bushings may be used as a bushing material.

3.3.1.4.2 Magnesium

Magnesium and magnesium alloys shall not be used.

3.3.1.4.3 Structural Application Castings

The use of castings for structural applications shall require procurement activity approval. Castings shall be classified in accordance with approved specification (ref.: Castings, Classification).

3.3.2 Parts

3.3.2.1 Standard Parts

Standard parts (MS, AN or JAN) may be specified in the supplier's design whenever they are suitable for the purpose.

3.3.2.2 Interchangeability

All parts having the same supplier's part number shall be functionally and dimensionally interchangeable.

3.3.2.3 Bearings

The wheel bearings shall be of the tapered roller type, of aircraft quality conforming to approved specification (ref.: Bearing, Tapered Roller).

3.3.2.4 Bolts

Bolts heat-treated to a minimum of 125 KSI for general structural applications shall conform to approved specification (ref.: Bolt, Aircraft, 60 KSI – 125KSI). Bolts heat treated from 160 KSI to 180 KSI shall conform to approved specification (ref.: Bolt, Aircraft, 160 KSI – 180 KSI). Bolts heat-treated from 180 KSI – 200 KSI shall conform to approved specification (ref.: Bolt, Aircraft, 180 KSI – 200 KSI). High strength bolts of greater than 200 KSI ultimate tensile may be used subject to the procuring activity approval (reference Paragraph 2). Corrosion resisting steel bolts in temperatures not exceeding 1200°F shall conform to approved specification (ref.: Bolt, Aircraft, 1200°F). Steel bolts smaller than 0.25 inch diameter shall not be used in any single-bolted structural connection or any application where a failure would adversely affect safety of flight. Aluminum alloy bolts, nuts, and screws may be used in nonstructural lightly stressed aluminum alloy parts. Structural bolts that are loaded in tension shall be pre-stressed to a value consistent with minimizing the effects of fatigue in the joint. The proper bolt-torque values shall appear in the applicable maintenance document. Where it is necessary to use a single attachment bolt with the head down in an application where its loss would affect safety of flight, the head of the bolt shall be lock-wired or retained in position independent of the attaching nut. Cadmium plated steel bolts or nuts used with aluminum alloy parts shall be insulated from the aluminum alloy with aluminum washers beneath the bolt head and nut, except that cadmium plated steel washers may be used for bolts loaded in tension.

3.3.2.5 Bushings

Bushings shall be provided for all bolts or pins subject to angular or other motions that would tend to distort or enlarge the hole. Bushings shall be securely anchored (an interference fit is acceptable) to the member to preclude slippage or movement. Bushings shall assume all wear or deformation at the joint and be readily replaceable. Peen or staking is prohibited. A bushing, however, with a very close sliding fit may be used as a sliding spacer to take up accumulated width tolerances. This may be done so that a fitting shall not be deformed due to torque with attachment bolt, for example: When using a sliding bushing to clamp the inner race of a bearing without deforming the basic fitting. In the event the inside diameter of a bushing is distorted out of round during the press fit operation, the bushing shall be reamed to size after installation. Reestablishment of the finish after reaming shall be required. Where the shoulders of two bushings are in sliding contact, the shoulder of one of the bushings shall be hard chrome plated or otherwise treated to form a suitable bearing surface. All holes in the wheel and brake assembly which are used for the purpose of a bolted joint or pin bearing journal shall be designed to accept a bushing for repair that is (.060 inch) over the normal bushed hole diameter, whether the original hole is bushed or not.

3.3.2.6 Fittings

3.3.2.6.1 General

Structural fittings shall be made from aluminum, steel or titanium alloys within the limitations imposed per this specification or other applicable specifications. Connections of solid end fittings to wheel and brake assembly using aluminum alloy rivets shall be suitable for possible replacement of rivets by the next larger size. Steel rivets or bolts may be substituted for aluminum alloy rivets subject to approval by the procuring activity. Abrupt changes in cross section shall be avoided. The minimum fillet radius for structural parts shall be 0.110 inch. Where justified by design, if not critical in fatigue, smaller radii may be used if verified by analysis and test, subject to the procuring activity approval. This requirement also applies to spot faces, counterbores, countersinks, and recesses.

3.3.2.6.2 Threads

In case of structural fittings produced from steel that is heat-treated in excess of 125 KSI and incorporates a threaded portion loading primarily in tension, the threads shall conform to approved specification (ref.: Threads, Controlled Root Radius). The threads shall be rolled in a single pass after heat treatment.

3.3.2.7 Packing, O-Rings and Gaskets

Scarf cut back-up rings shall not be used in wheel and brake assemblies. Packings, O-rings, and gaskets for wheels shall conform to approved specification (ref.: Packing, Preformed). The supplier may propose alternative specifications and standards for protective treatments per Paragraph 2.

3.3.2.8 Pins

The use of friction-retained pins without auxiliary means of retention, such as nuts and cotter pins, is prohibited (e.g. groove pins, taper pins, etc.). Peen, staking or safety wiring is not acceptable for pin retention. Roll pins shall be prohibited. Rotating pins or bolts shall be hard chrome plated in accordance with procedures note herein.

3.3.2.9 Washers

Washers used in internal wrenching or other similar high strength type bolts shall conform to approved specification (ref.: Washer), except in cases where special washers, chamfered on both sides are required to prevent improper installation. Washers used with other structural fasteners shall conform to approved specification (ref.: Washer, Structural Fastener). Lock washers and metallic crush washers shall not be used.

3.3.3 Processes

3.3.3.1 Stress Corrosion Factors

Sustained or residual surface tensile stress and stress concentrations shall be minimized to prevent premature failures caused by stress corrosion or hydrogen embrittlement. This requirement applies to design, manufacturing method, assembly and installation techniques. Practices such as the use of press or shrink fits, taper pins, clevis joints in which tightening of the bolt imposes a bending load on the lugs, and straightening and assembly operations, that result in sustained or residual surface tensile stresses shall be avoided. In cases where such practices cannot be avoided, corrective practices such as stress relief heat treatments, optimum grain flow orientation, shot peen or similar surface working shall be used to minimize the hazard of stress corrosion or hydrogen embrittlement damage.

3.3.3.2 Fatigue Factors

Sustained or residual tensile stresses and stress concentrations shall be minimized to prevent premature failures caused by repeated loads. This requirement applies to design, manufacture method, assembly, and installation techniques. Consideration shall also be made for the damaging effect of decarburization and certain metallic coatings. Practices such as cold straightening, cold forming, and the assembly of mismatched surfaces, that result in sustained or residual surface tensile stresses shall be avoided. Corrective practices such as stress relief heat treatment, optimum grain flow orientation, shimming, shot peen or similar surface working shall be used to minimize premature fatigue failure, subject to approval by the procuring activity. Surface roughness of elements subject to repeated stresses shall not be in excess of 125 rms as defined in approved specification (ref.: Surface Texture). Particular attention shall be given to optimum heat treatment procedures, corrosion protection, and finish to minimize corrosion damage that may be the site of premature fatigue failure.

3.4 Protective Treatment

Protective treatments shall be selected to accomplish the designated performance requirements. Protective treatments shall comply with approved specification (ref.: Protective Surface Treatments). The supplier shall be responsible for protective treatments that provide reliable performance, with regard to the interface and all possible operating environments. All protective treatments shall be maintainable by processes that are available from at least two commercial sources.

The supplier may propose alternative specifications and standards for protective treatments per Paragraph 2.

3.4.1 Painting

3.4.1.1 Painting - Heat Properties

To protect wheels, brakes, and tires from the detrimental effect of heat generated in or transferred to the components, surface treatments authorized herein shall be used in such a manner as to make maximum use of their heat-retarding, absorbing, and dissipating properties, if applicable, regardless of color.

3.4.1.2 Painting - Oil

Paint need not be applied to parts that are constantly immersed in or covered with oil. Oil shall not be applied to surfaces where it would impair proper functioning.

3.4.1.3 Painting - Flanges

For demountable flange-type wheels, the portion of the hub on which the demountable flange rests and the inner surfaces of the demountable flange shall be primed but shall not be painted. Allowance for dry film lube is preferred in these areas over the primer to minimize fretting and to aid in disassembly.

3.4.1.4 Painting – Color

The topcoat color for the wheel and brake shall be predominantly grey (Color No. 16475) and comply with approved specification (ref.: Paint, Colors).

3.4.1.5 Painting – Aluminum

The exterior surface of anodized aluminum and aluminum alloy parts shall be protected with one coat of primer followed by sufficient coats of polyurethane to meet the supplier's specification. Alternative treatment such as heat-resistant aluminum paints, phosphate ester resistant epoxy paints, and others may be used when authorized by the procuring activity (reference Paragraph 2).

3.4.2 Anodized Aluminum

All aluminum and aluminum alloy parts shall be anodized (ref: Anodized). Aluminum pistons shall be hard anodized per the same specification to reduce galling if the seal is contained in the cylinder wall.

3.4.3 Steel Plating

all steel parts shall be plated. The parts that reach temperatures that are detrimental to plating need not be plated, but other protective means for corrosion protection shall be provided.

3.4.3.1 Chromium

Chromium plating shall comply with approved specification (ref.: Plating, Chromium). Plating shall be applied directly on steel and at a rate not to exceed 0.0005 inch per hour.

3.4.3.1.1 Chromium – Heat Treatment

Parts heat treated to 240 KSI and above shall be baked at 375°F +/-25°F within 3 hours after plating for a minimum of 23 hours. After grinding of chrome plate 220 KSI and above, all parts shall be baked at 375°F +/-25°F for 3 hours.

3.4.3.1.2 Chromium – Embrittlement Relief

Parts heat treated to 220 KSI – 240 KSI range shall heave at least a 24-hour 375°F +/-25°F bake for embrittlement relief.

3.4.3.1.3 Chromium – Thickness

The minimum thickness shall be 0.002-inch for all chrome-plated parts except the piston, which shall be 0.0035-inch minimum.

3.4.3.1.4 Chromium – Shot Peen

Prior to plating, parts shall be shot peened with 200% coverage in compliance with approved specification (ref.: Shot Peen, Metals).

3.4.3.2 Steel Plating - Zinc

Zinc Plating shall be processed in compliance with approved specification (ref.: Plating, Zinc). Zinc plating shall not be used on parts where the in-service temperature may exceed 600°F.

3.4.3.3 Cadmium

Cadmium plating shall be electrodeposited in compliance with approved specification (ref.: Plating, Cadmium-electrodeposition), except steel parts heat treated to 220 KSI – 240 KSI range, which shall be vacuum deposited in compliance with approved specification (ref.: Plating, Cadmium, Vacuum Deposit). Any other process shall be subject to the procuring activity approval. Cadmium plating shall not be used on parts where the in-service temperature may exceed 450°F.

3.4.3.4 Tin

Tin plating in compliance with approved specification (ref.: Plating, Tin) shall be used in lieu of cadmium plating where flaking may tend to contaminate equipment in contact with hydraulic fluid or may be used where applicable.

3.4.3.5 Steel Plating Exceptions

Plating on springs is not required. Corrosion resistant steel parts need not be plated unless required for dissimilar metal interface or functional reasons. Corrosion resistant steel parts shall be passivated in compliance with approved specification (ref.: Passivation).

3.4.4 Titanium

Surface treatment of titanium and titanium alloys shall be as approved by the procuring activity prior to use, per Paragraph 2.

3.4.5 Name Plates

The backs of mechanically attached nameplates, instruction plates and designation plates shall be primed. Upon installation, the rear of these plates shall be sealed. The faces of all plates shall be covered with a urethane clear coat after annotating info on the plates.

3.4.6 General Coating Conditions

Paint shall not be applied to brake lining, brake discs or bearing race surfaces. The bearing and braking surfaces shall be masked during the application of finish to the wheels and brakes. Surface treatments other than those noted shall be subject to the procuring activity approval prior to use per paragraph 2.

3.5 Detail Design

The main wheel and brake assembly shall be designed to accomplish the performance requirements specified herein.

3.5.1 General

The configuration shall be compatible with the total aircraft performance, maintenance, and operational environment. General design characteristics shall include the following:

a. Tolerate external loads and braking action that may be associated with proper performance during brake application while the aircraft is steered through a turn.
b. Be designed for installation at both main landing gear axle positions.
c. Be suitably formed to provide external contours as smooth and free from projections as practical.
d. Be furnished without fairings or provisions for fairings.
e. Allow for wheel removal without removing the brake.

3.5.1.1 Configuration Management

Articles furnished in accordance with this specification shall be configured and produced under a system of configuration management consistent with good commercial practices. Configuration review meetings between the supplier and the procuring activity shall be held periodically.

3.5.1.2 Safety

The wheel and brake assembly shall be designed to preclude the incorporation of features that result in critical or catastrophic hazards as classified in approved specification (ref.: Safety).

3.5.1.3 Improper Assembly

Wheels and brakes shall be designed to preclude improper assembly and installation.

3.5.1.4 Wheel and Brake Clearance

Wheels and brakes shall be designed so that there is adequate clearance between the wheel and brake under all conditions. The requirement shall include consideration of tolerance stack-ups, free-play, axle and brake structure deflections, thermal expansion, etc. Brake pistion housing shall also clear the landing gear jack pad under all operating conditions, including gear retraction, extension, and stowage, etc..

3.5.1.5 Vibration and Shock

The wheel and brake assembly shall be capable of simultaneously withstanding the maximum acceleration in the radial direction (landing) and in the rotational direction occurring during aircraft operations without impairing the function of the wheel and brake assembly. The brake shall perform satisfactorily in any aircraft environment during service. Brake induced vibrations shall be stable and sufficiently damped to not cause damage to internal wheel or brake parts, degrade braking performance or damage any other part of the aircraft structure or systems.

3.5.1.6 Rework Allowance

Sufficient rework material shall be provided to allow rework and repair of base material in historically troublesome areas such as bearing bores, wheel tie bolt bosses, wheel drive bar/key interface, inflation/overinflation valves and fuse plug bosses, and brake attachment bushings.

3.5.1.7 Moisture Entrapment

The wheel and brake assembly shall be designed to prevent the entrapment of moisture in any position from fully extended to fully retracted. This may be accomplished by effectively sealing enclosed areas against the entrance of water or by providing adequate drainage. Cork seal, dams, and metal end plugs machined to fit shall not be used.

3.5.1.8 Total Weight

The total weight of the wheel and brake assembly shall be a minimum consistent with good design. Maximum wheel and brake assembly weight shall not exceed 63 lb. The Supplier shall be responsible for maintaining and reporting wheel and brake assembly weights before shipment. Total weight includes wheel bearings and hydraulic fluid within the brake piston housing.

3.5.1.9 Environmental

The equipment shall not suffer damage, deterioration or degradation of performance beyond the limits of this specification when subjected to any environment or any natural combination of environments specified herein and in approved specification (ref.: Test, Environmental). The environmental requirements are design conditions and similarity and analysis may verify some of the requirements.

3.5.1.9.1 Air Temperatures

The equipment shall be capable of meeting the requirements of this specification during and after exposure to the following ambient air temperatures:

a. Storage: -80°F to +185°F

b. Operating: -65°F to +160°F from sea level to 15,000 feet

3.5.1.9.2 Altitude

The equipment shall be capable of meeting the requirements of this specification during and after exposure to pressures encountered from sea level to the maximum operational altitude.

3.5.1.9.3 Humidity

The equipment, under both operating and non-operating conditions, shall be capable of meeting the requirements of this specification during and after extended exposure to relative humidity up to 100%. This includes conditions where condensation takes place in and on the equipment.

3.5.1.9.4 Salt Atmosphere

The equipment, under both operating and non-operating conditions, shall be capable of meeting the requirements of this specification during and after exposure to salt-sea atmosphere as encountered in seaside service.

3.5.1.9.5 Fungus

The equipment, under both operating and non-operating conditions, shall be capable of meeting the requirements of this specification during and after indefinite exposure to fungus growth as encountered in tropical climates

3.5.1.9.6 Sand and Dust

The equipment, under both operating and non-operating conditions, shall be capable of meeting the requirements of this specification during and after extreme exposure to sand and dust particles as encountered in desert areas.

3.5.1.10 Reliability

The reliability requirements of this performance specification shall be applicable under all operating conditions. The mean cycles between failure (MCBF) of the wheel and brake assembly shall be equal to or greater than 4000 cycles. A cycle is defined as one take-off and one full stop landing, including taxi to and from the ramp. A failure is defined as the inability to meet the requirements of this performance specification. Conditions requiring wheel and brake assembly maintenance for correction of incipient failures observed during inspections are not considered to be failures.

3.5.1.11 Maintainability

3.5.1.11.1 Quantitative Maintainability

The wheel and brake assembly shall be designed to meet the following quantitative maintainability requirements:

a. Wheel Assembly on-aircraft – 2,000 MCBUM / 0.8 Hours MTTR
b. Wheel Assembly off-aircraft – 0.3 Hours MTTR
c. Brake Assembly on-aircraft – 1,000 MCBUM / 0.6 Hours MTTR
d. Brake Assembly off-aircraft – 0.3 Hours MTTR

Where:
MCBUM = Mean Cycles Between Unscheduled Maintenance
MTTR = Mean Time to Repair

3.5.1.11.2 Qualitative Maintainability

The wheel and brake assembly shall be designed and constructed to satisfy the following qualitative maintainability requirements:

a. Required on-aircraft maintenance shall be accomplished without any specialized skills or tools. Design for repair by Air Force skill level 3 (apprentice level) shall be a design objective. Support equipment, tools and test equipment required for repair and overhaul shall be standard Air Force items to the maximum extent possible.
b. The design of repairable items and their components shall be such that the items may be supported by replacement of interchangeable parts or subassemblies.
c. Modules or components that perform a common function shall be interchangeable to the greatest extent possible, however if components are not structurally or functionally interchangeable they shall not be physically interchangeable.
d. Wheels shall be such that preflight, post-flight, and phase inspections can be accomplished on aircraft by look-see methods requiring no disassembly.
e. The tire change time counter shall be located so as to be directly readable without mirrors or other devices, at any point of wheel rotation.
f. Wheel halves shall be so balanced that no possible rotational index shall effect balance of the complete wheel and bearings assembly beyond the requirements of this performance specification or shall be so designed that assembly in proper index only can be made.
g. Wheels shall carry suitable wording (highlighted in red), warning against loosening of wheel tie bolts without first releasing tire pressure.
h. Brake wear indicators shall be so located as to be readable without mirrors or other devices. The indicators shall have go/no-go limits clearly identified.
i. Brake assembly LRU's shall be capable of pre-wheel installation alignment with no, or minimum, aerospace ground equipment.
j. Bleeder valves and service tubing connections shall be readily accessible on-aircraft.
k. Brakes shall not require manual adjustment throughout their wear life. A method for determining that brake-running clearance is present without support equipment shall be provided.
l. Design shall provide for on-aircraft maintenance by technicians wearing arctic clothing.
m. Components shall be configured to minimize potential damage due to debris, heat, tire burst or tread separation, or normal operations and maintenance.

3.5.1.12 Auxiliary Features

The inclusion of any auxiliary feature in the wheel or brake design, such as a tire pressure monitoring system, shall require a formal demonstration, and the procedure and results shall be approved in writing by the procuring activity.

3.5.1.13 Identification of Product

Marking shall be performed in compliance with approved specification (ref.: Marking). Additional markings not stated within the requirements shall be approved by the procuring activity.

3.5.1.13.1 Wheel Marking

Integral lettering shall be required, automated dot peen is acceptable; nameplates or metal stamping shall not be used. Wheels shall carry the following information:

a. Size
b. Supplier's name and part numbers on both components and assemblies.
c. Serial number on both wheel halves, on demountable flange and wheel body or, in the case of other designs, on similar major wheel parts.
d. Date of manufacture (month and year, i.e. Date Manf - Jan 2003).
e. All tie-bolt type wheels shall carry a warning note to require deflation of the tire before loosening of the tie bolts. This note shall be highlighted in red after painting the wheel.

f. Tie-bolt type wheels shall carry a suitable note to clearly describe the method of torque values used in tightening the tie-bolts. The note shall read: Lubtork/Molytork per T.O or CMM.
g. Raised bosses in the wheel flange region shall be provided to dot peen overhaul information.
h. Provisions for 2-dimensional bar coding shall be provided in an easily readable location with part number, serial number, and manufacture date.

3.5.1.13.2 Brake Marking

Automated dot peen or stamping is preferred. Integral lettering is acceptable. Brake piston housings shall carry the following information:

a. Supplier's name and part numbers on both components and assemblies.
b. Serial number
c. Date of manufacture (month and year, i.e. Date Manf – Jan 2003).
d. Hydraulic fluid type
e. Caution note on carbon heatsink brakes, "Do not apply paints, cleaners or deicers or temp sticks to carbon disks."
f. Provisions for 2-dimensional bar coding shall be provided in an easily readable location with part number, serial number and manufacture date.

3.5.1.13.3 Location of Marking

Assembly Part numbers shall be located to be readable after installation of the part on the aircraft. Subassembly and detail part numbers shall be located to be readable after assembly in the complete unit whenever possible. Markings shall be located so that they shall not be obliterated or effaced as a result of service usage or become illegible due to the application of paint. Markings shall be as large as possible for the application area.

3.5.1.13.4 Part and Subassembly Marking

Each part and subassembly, except the following, shall be permanently marked with the appropriate part or subassembly part numbers:

a. Those that are permanently assembled by welding, brazing, soldering or riveting shall carry the subassembly part number.
b. Those that do not have suitable or sufficient surface for the part number.
c. Those upon which marking would impair the function or structural integrity.

3.5.1.13.5 Age Control, Packings and Gaskets

The wheel and brake assembly shall be supplied with suitable markings showing the date of assembly or reassembly of the equipment in quarter-of-year and year; e.g., 3Q03 representing the third quarter of 2003. Acceptable methods of marking shall be by decal or indelible ink stamping. The age of the oldest packing and/or gasket, at the date of assembly or reassemble of the unit shall not exceed 36 months.

3.5.2 Wheel Design

The design of wheels shall be of the demountable flange type or of the divided type to facilitate changing the tire. Demountable flanges or divided wheels shall be designed so that a failure of the joining bolts or retaining device results in a benign failure where tire pressure is rapidly released eliminating the possibility of an explosive separation of a wheel half or flange. Wheels shall be designed for compatibility with both radial and bias tires.

3.5.2.1 Rim Contours

The wheel rim contour shall conform to the rim contour standard for the particular tire listed in the approved specification (ref.: Tires, Aircraft Pneumatic). In cases where standards do not exist, the rim contour shall conform to the specification control drawing or to the one recommended by Tire and Rim Association. It shall be the responsibility of the supplier to ensure satisfactory tire dismountability of the designed rim contour on any tires already approved for the application. The valve installation shall form a part of the wheel assembly. It shall use a standard core and cap and shall be conveniently usable with standard inflating and gauging chucks. The location of the inlet into the tire shall be as shown on the applicable rim contour standard or the specification control drawing or as recommended by the Tire and Rim Association standard.

3.5.2.1.1 Rim Surfaces

The surface of the wheel rim between bead seats shall be free from defects or casing protrusions. Tire Bead Seat surfaces shall be smooth. No knurling or abrasion of surface shall be allowed.

3.5.2.1.2 Rivets

Rivets shall not come in contact with the tire.

3.5.2.1.3 Smoothness of Surfaces

After surface treatment and prior to application of surface coatings, machined surfaces shall not exceed the following surface finish in terms of Microinch rms maximum:

a. (32) for Bead seat and radii, demountable flange lock ring grooves and similar stress radii.
b. (125) for Radii between flange faces and outside diameter of flanges; also recesses for bearing cups.
c. (250) for Rim surface between bead seats.

In lieu of the surface finish specified, alternative-processing methods may be used in the areas noted, subject to the approval of the procuring activity per paragraph 2. Except as specified above, surfaces of non-machined sections of the wheel, such as spokes, ribs, and rims between bead seats, shall be of reasonably fine-grained appearance. Burrs and fins shall be removed by grinding.

3.5.2.2 Demountable Flange Wheels

The demountable flange shall be on the outboard side of the wheel. All demountable flanges shall be locked to the wheel in a manner that shall prevent the removable flange and its retaining device from leaving the wheel in case a flat-tire/bare-rim occurs while the wheel is rolling. Design consideration shall be given to protection against corrosion and fretting. The flange inside diameter shall be dry film lubricated.

3.5.2.3 Wheel Tie Bolt and Boss

Wheel tie bolts, where used, shall be of the through-type with nuts; no inserts shall be permitted. Inconel is preferred to the use cadmium plating due to maintainability issues. Appropriate MS head form bolts or equivalent shall be used. Appropriate thread lubricant and torque values shall be specified with appropriate substantiation. Torque values shall not appear on the wheel or brake physically and shall be identified only in the applicable technical manual. The wheel tie bolts, nuts, and washers combination shall be as follows:

a. Tie Bolt – OEM selected, 220 KSI maximum
b. Nut – OEM selected, 220 KSI equivalent
c. Washer – OEM selected to meet requirements herein.

3.5.2.4 Wheel Torque Takeout Devices

Beam keys are preferred over shell type keys. The key wear faces of the torque takeout feature shall be hard coated with HVOF WC-Co coatings to prevent wear.

3.5.2.5 Wheel Heat Shielding

Heat shielding shall be provided as required to minimize heat transfer between the brake heatsink and the wheel. The following wheel heat shield design features shall be incorporated:

a. Segmented design to facilitate wheel maintenance and spare part storage.
b. Secure and undistorted wheel installation that prevents fretting of the wheel.
c. Materials and drains that tolerate heat shield immersion (heat shield shall not contain absorbent materials capable of retaining cleaning solvents).
d. Stiffness/protection that minimizes damage from wheel/tire assemblies leaning against a pole and bearing on the heat shield.
e. Wheel heat shield shall be capable of being removed without removing the wheel drive keys.

3.5.2.6 Wheel Bearings

3.5.2.6.1 Wheel Bearing Fit

Means shall be incorporated to avoid improper assembly of wheel bearings with the wheel. The wheel bearing bore and seat shall be designed to allow a 0.060 inch wall steel sleeve repair.

3.5.2.6.2 Lubricant and Lubricant Retainers

Suitable retainers shall be provided to prevent lubricant from reaching the braking surface and to prevent foreign material from entering the bearings. The retainers shall be removable to allow for cleaning and lubrication of the bearings, and shall retain wheel bearings for transport to the aircraft for wheel installation. Wheel bearings shall be sealed on a stationary surface. Wheel bearing seals shall not be designed to rub on the stationary or permanent portion of the brake housing or strut. Rubbing surface shall be on an individual part that is inexpensive to replace so that any wear shall not cause condemnation of the brake or strut. Applicable requirements shall be observed, (ref.: Lubrication, Military Equipment & Lubricant, Selection Guide). A suitable lubricant shall be specified.

3.5.2.6.3 Lubrication Fittings

Wheels shall not be fitted with pressure type lubrication fittings.

3.5.2.7 Wheel Mating Seals and Grooves

Seals and grooves shall conform to approved specification, (ref.: Seal, Wheel Static). Seal compounds conforming to approved specification (ref.: Rubber, Elastomer) shall be used.

3.5.2.8 Tire Valves

3.5.2.8.1 Wheel Valve and Boss

Tubeless tire valves shall conform to approved specification, (ref.: Valve, Filler). The valve boss shall conform to approved specification, (ref.: Boss, Port). Where possible, the wheel valve and boss design shall comply with the current year Tire & Rim Association standards - valve assemblies and components shall be placed upon the wheel suppliers drawing format for procurement purposes.

3.5.2.8.2 Valve Cores

Valve core assemblies shall be selected from Tire & Rim Association standards currently in use with the military services.

3.5.2.8.3 Over-inflation Protection Devices

Over-inflation protection devices shall be provided, (ref.: Pressure Relief Devices). The over-inflation valve shall contain or deflect any objects related to its release, such as a broken diaphragm or ice particle, away from a person who may be servicing the tire at the time of release.

3.5.2.8.4 Braked Wheel Thermal Sensitive Pressure Release Devices (Fuse Plugs)

A minimum of three eutectic fuse plugs (ref: Fuse Plug, Thermal) shall be provided and located in the wheel tube-well area approximately equally spaced about the wheel. Fuse plug ports shall be designed and located to allow rapid and unobstructed release of tire pressure. The fuse plug rated temperature shall be permanently marked on the face of the plug body. Fuses shall be designed to protect aircraft design integrity at any wheel clocking position, and at the highest possible eutectic melt temperature, with no credit allowed for cooling breeze. Fuse plugs shall release the tire pressure before a maximum allowable operating temperature is reached at any location, including the wheel, brake, axle, and hydraulic fluid. The fuse plug design needs to allow rework or installation of oversized fittings.

3.5.2.9 Static Balance

Wheel halves shall be statically balanced without weights, with asymmetrical or nonsymmetrical components installed within 3 ounce-inches. Assembly of the two wheel halves of a split-type wheel assembly in any possible relative position or assembly of halves of different wheels shall not result in unbalance beyond the limit. Static balance operations for wheels shall be omitted.

3.5.3 Brake Design

3.5.3.1 Brake Actuation

3.5.3.1.1 Brake Operating Pressure and Release

The brake design shall be compatible with the full range of operating pressures provided by the aircraft brake hydraulic system, and shall fully release to the design running clearance at pressure not less than 110% of the maximum steady state back pressure at the brake.

3.5.3.1.2 Brake Inlet and Bleeder Fittings

Brake inlet fittings, threads, and bosses shall conform to approved specification (ref.: Hydraulic Systems (ACFT Type I & II)). Brake bleeder valves shall conform dimensionally to approved specification (ref.: Valve-Hydraulic Bleeder) and installed in a boss, inlet fitting or attaching bolt machined in accordance with approved specification (ref.: Boss, Port). A threaded steel insert shall be provided for inlet bosses in nonferrous brake housings. All fittings shall be safe-tied or suitably locked. Self-sealing couplings, if required by the procurement specification, shall conform to approved specification (ref.: Coupling Assembly, Hydraulic).

3.5.3.1.3 Brake Fluid Passageways

Hydraulic fluid passageway restrictions shall not be less than 0.070-inch diameter.

3.5.3.1.4 Brake Seals and Glands

Piston cylinder design shall conform to approved specification, (ref.: Gland Design, PackingO-rings and other elastomeric seals). Fluorocarbon shall be used for dynamic sealing and fluorosilicon packing shall be used for static sealing applications. Other configuration seals may be used with prior approval from the procuring agency per paragraph 2. Consideration may be made for high temperature applications. Seals and glands shall be drawing controlled by the approved supplier. Special bullets and solid back-up ring resizing tools to protect O-rings on installation and maintain back-up rings to correct size and shape are required to prevent premature brake failures.

3.5.3.1.5 Piston Liners

Brake piston liners shall be included in the piston assembly and be designed to be replaceable. If aluminum pistons or piston liners are used, the surfaces wiped by dynamic seals shall be hard anodized. The piston liner-to-piston housing thread shall be on the "wet" side of the static seal to facilitate corrosion prevention.

3.5.3.1.6 Brake Piston Stops

Piston stops shall be provided to stop the piston from falling out and prevent loss of hydraulic fluid when overextended. The piston stops shall allow piston travel after a maximum design gross weight rejected takeoff at the 100% worn brake condition with the maximum operating hydraulic pressure applied. The stops shall be designed for 1.5 times the maximum operating pressure without the brake heatsink installed.

3.5.3.1.7 Brake Piston Adjusters

The maximum fluid displacement of the brake shall be a maximum of 1 in^3. Fluid displacement must include running clearance and brake compliance. The displacement after brake contact shall be minimized to optimize pressure control at the brake, with minimum flow.

3.5.3.1.7.1 Brake Automatic Adjusters

Automatic adjusters shall be provided to compensate for brake lining wear. Brake assemblies shall be designed for the most practical protection of the brake adjusters. Adjuster function and reliability shall be substantiated in the supplier's proposal.

3.5.3.1.7.2 Brake Running Clearance

The designed running clearance shall be maintained at all wear stages and operating conditions of the brake. Running clearance shall be designed so that a dragging brake shall not be possible with consideration for tolerance stack-ups, free-play, axle and brake structure deflections, thermal expansion, etc. Running clearance shall also be designed to minimize brake hydraulic response time.

3.5.3.2 Brake Wear Indication

The brake assembly shall have wear indicators visible when performing a walk around inspection with readily identifiable "go-no go" limits without requiring measurement. Wear pins shall require no adjustment or trimming (i.e. a spring loaded mechanism that automatically seats to pressure plate and adjusts wear pin length is preferred). Wear indication reference surfaces on the piston housing shall be non-adjustable.

3.5.3.3 Brake Housing

3.5.3.3.1 Brake Bolt Holes

Brakes shall be designed so that bolt holes can be reworked with replaceable bushings to correct for wear or corrosion of the base metal.

3.5.3.3.2 **Brake Backup Structure**

The brake backup structure shall be designed to promote even brake disk pressure and wear radially across the friction surface.

3.5.3.4 **Brake Heatsink Material**

Steel, carbon, ceramic, or other proposed new material, shall be justified by design and validated with test or service data.

3.5.3.4.1 **Brake Heatsink Torque Takeout**

Structural composites for brake heatsink material, where justified by design and validated with test or service data, shall be subject to procuring activity approval. When the brake employs a structural composite heatsink, the rotor lugs shall use clips or metallic structure to protect against damage. Chamfered entry shall be used on wheel keys and/or clips to facilitate alignment during wheel installation. Stator lugs shall be protected against wear and oxidation damage by either clips or some treatment on the steel brake structure.

3.5.3.4.2 **Heatsink Clips**

Structural composite brake heatsink clips shall last the wear-out life of the heatsink. Clips shall be retained either directly or indirectly with stainless steel. Monel rivets shall not be used in a structural composite heatsink.

3.5.3.4.3 **Heatsink Oxidation Protection**

Exposed surfaces of a structural composite heatsink shall be coated to protect against oxidation. The coating shall be formulated to provide adequate protection and not have an effect on the friction properties of the wear surfaces. The oxidation coating shall provide continuous protection throughout the life of the heatsink at least as long as the wheel thermal fuses have not released. The oxidation coating shall not be prone to absorb moisture during aircraft down time that adversely effects brake torque. Oxidation coatings selected shall be service proven and have substantial test data supporting their ability to operate in humid environments during long layover periods without adversely effecting brake torque.

3.5.3.4.4 **Heatsink Contamination Protection**

The heatsink material shall be selected and designed with consideration for the fact that it shall be exposed to levels of contamination in normal service including ice control materials, wash chemicals, paint, hydraulic fluids, solvents, and etc. The heatsink shall deliver specified performance when subjected to normal service contaminates. General wheel and brake design shall protect the vulnerable areas of the heatsink from contaminants, including dirt and FOD.

3.5.3.4.5 **Heatsink Stator Scribe**

Stators shall include a scribe mark on the outside diameter in a specific location that is visible when the brake is installed and the wheel is removed. Stators shall be clocked on installation so that the scribe marks of all stators are in the same circumference location. The scribe mark shall provide positive indication that the stator lugs are engaged properly. The scribe mark shall be visible throughout the life of the heatsink.

3.5.3.4.6 **Heatsink Refurbishment**

The heatsink may be designed to take advantage of refurbishment methods such as 2-for-1 or thick-thin disks. The refurbishment method shall be included in the design proposal along with a qualification plan.

3.6 Performance Requirements

3.6.1 Wheel Performance

3.6.1.1 Wheel Pressure Performance

3.6.1.1.1 Wheel Burst Performance

The wheel shall be capable of exceeding a minimum burst pressure 3.5 times the rated inflation pressure.

3.6.1.1.2 Wheel Over-Inflation Valve Performance

The over-inflation valve shall release pressure faster than the maximum wheel inflation rate.

3.6.1.1.3 Wheel Static Pressure Retention Performance

When inflated to 1.5 times the rated inflation pressure the rate of leakage for the wheel and tire assembly shall not exceed 4 bubbles per second (excluding tire vent holes) when completely immersed in water.

3.6.1.1.4 Wheel Pressure Diffusion Performance

The wheel and tire assembly shall hold the rated, loaded inflation pressure for 24 hours with no greater pressure drop than 5 psi. The tire shall be grown and stabilized in compliance with approved specification (ref.: Tires, Aircraft Pneumatic) before the 24 hour period.

3.6.1.1.5 Wheel Dynamic Pressure Retention Performance

The wheel and tire assembly shall not drop in pressure by more than 5 psi, after rolling 25 miles at the rated static load of the wheel. The tire shall be grown and stabilized in compliance with approved specification (ref.: Tires, Aircraft Pneumatic) before the 25 mile roll.

3.6.1.2 Wheel Static Performance

3.6.1.2.1 Wheel Yield Combined Load Performance

The wheel assembly, including bearing assemblies, shall support the components of the yield-combined load specified in Table – 3 (Wheel Performance Parameters) for a minimum of 10 seconds, applied at any position about the wheel circumference with side loads applied in either the inboard or outboard direction. There shall be no yielding of the wheel that would result in loose bearing cups, air leakage through the wheel or past the wheel seal, or interference in any critical clearance areas resulting in damage or impaired performance of the wheel and brake assembly. The main wheel shall be tested with the brake installed and it shall be determined that no interference exists. Repeated loading at one position shall not cause permanent set increments of increasing magnitude.

3.6.1.2.2 Wheel Ultimate Combined Load Performance

The wheel assembly shall support the ultimate combined load specified in Table – 3 (Wheel Performance Parameters) for a minimum of 10 seconds after which there shall be no cracks in any area.

3.6.1.3 Wheel Dynamic Performance

3.6.1.3.1 Wheel Roll Performance

The roll life of the wheel shall be as shown in Table – 4 (Wheel Roll Spectrum) and shall not result in cracks or other evidence of failure. The roll life shall account for brake and tire induced thermal conditioning experienced in service. No replacement of assembly parts, except for bearings, shall be allowed during the roll life of the wheel.

3.6.1.3.2 Wheel Roll to Failure Performance

When the wheel fails as a result of fatigue it shall fail a benign non-explosive mode.

3.6.1.3.3 Wheel Roll on Rim Performance

The wheel assembly shall be capable of rolling without a tire for a distance of 15,000 feet at a minimum speed of 10 miles per hour while at the full rated static load with normal axle deflection. The wheel shall roll the distance without fracturing to the extent that the wheel can no longer roll at the required load. No part of the wheel shall depart the assembly prior to failure.

3.6.2 Brake Performance

Unless stated specifically, performance requirements apply to brakes at any wear state, from brand new to fully worn.

3.6.2.1 Brake Torque and Energy Performance

Average braking friction coefficients shall be repeatable within +/- 15% for brake energy values up to and including normal energy braking. Average braking friction coefficients shall be repeatable within +/-10% for brake energy values above normal energies and during static torque conditions.

3.6.2.1.1 Brake Static Torque Performance

At maximum hydraulic operating pressure, the brake shall generate static torque at least equivalent to the value specified in Table – 5 (Brake Performance Parameters) while subjected to any reasonable operating condition, including cold or hot brakes and dry or humid conditions.

3.6.2.1.2 Brake Torque Sensitivity Performance

Brake friction coefficient average weighted error score shall not exceed 0.9 for constant pressure stops for all conditions up to and including overload energy stops. Average weighed error scores shall be calculated per Figure 2 (Brake Friction Coefficient Limits).

3.6.2.1.3 Brake Peak Dynamic Torque Performance

The brake shall not produce a peak dynamic torque during any braking condition that exceeds the value specified in Table – 5 (Brake Performance Parameters). Any braking condition includes but is not limited to all possible conditions such as loaded and unloaded wheel, hot and cold brakes, heatsink wear state, metered pressure, pressure ramp rate, etc.

3.6.2.1.4 Brake Normal and Overload Performance

The brake shall produce normal and overload energy performance in compliance with the requirements specified in Table - 5 (Brake Performance Parameters). The brake shall be capable of completing a series of at least 100 normal stops and 5 overload stops. Free-rolling drag requirements shall be maintained throughout the series. The brake shall be capable of completing the series without the aid of cooling fans during braking conditions.

3.6.2.1.5 Brake RTO Performance

The brake shall produce RTO performance in compliance with the performance requirements specified in Table – 5 (Brake Performance Parameters). The worn brake RTO is for information only. However, the brake shall not initiate any fire that exceeds the height of the tire within 5 minutes of the RTO for both new and worn brake RTO tests.

3.6.2.1.6 Brake Rolling Drag Performance

Brake rolling drag shall not exceed the performance requirements specified in Table - 5 (Brake Performance Parameters).

3.6.2.1.9 Brake Torque Performance (Wet Brake)

The torque performance and structural integrity of the brake shall not be permanently degraded after prolonged exposure to water or humidity.

3.6.2.2 Brake Thermal Performance

Brake operation shall not result in temperatures exceeding the following limits prior to wheel thermal fuse release:

a. Wheel – 400°F
b. Brake Piston Housing – 400°F
c. Axle – 400°F
d. Hydraulic Fluid - 325°F

3.6.2.3 Brake Stability Performance

The brake shall be dynamically stable in all operating conditions. Sustained vibration modes shall not exceed 10g's amplitude at or below 1000 Hz and no more than 25g's between 1000 and 2000 Hz. Transient vibrations with duration less than 0.5 seconds shall not exceed twice the amplitude allowed for sustained vibrations.

3.6.2.4 Brake Hydraulic Performance

3.6.2.4.1 Brake Piston Housing Endurance Performance

The brake hydraulics shall withstand 100,000 cycles of full available hydraulic pressure without fatigue failure, malfunction or leakage.

3.6.2.4.2 Brake Piston Return Pressure Performance

When pressure is released all rotors shall freely rotate and piston to pressure plate running clearance shall be restored.

3.6.2.4.3 Brake Piston Housing Extreme Temperature Performance

3.6.2.4.3.1 Brake Piston Housing Aging and Heat Performance

The brake shall remain operational and not exceed allowable static and dynamic leakage rates while being heat soaked at 250±25°F for period of at least 168 hours.

3.6.2.4.3.2 Brake Piston Housing Cold Performance

The brake, having been previously aged and heated, shall remain operational and not exceed allowable static and dynamic leakage rates while being cold soaked at -65°F for a period of at least 72 hours.

3.6.2.4.4 Brake Leakage Performance

3.6.2.4.4.1 Brake Piston Housing Static Leakage Performance

The brake shall not experience measurable leakage (less than one drop) or permanent set during or after being subjected to hydraulic pressure equivalent to 150% of the maximum hydraulic operating pressure for a minimum time of 5 minutes.

3.6.2.4.4.2 Brake Piston Housing Dynamic Leakage Performance

Leakage at static seals shall not exceed a trace. Leakage at moving seals shall not exceed one drop of fluid per each 3 inches of peripheral seal length when the brake is subjected to 25 cycles of maximum hydraulic operating pressure.

3.6.2.4.5 Brake Static Pressure Performance

The brake shall be capable of being pressurized at 200% of maximum hydraulic pressure for a minimum time of 5 minutes with no evidence of leakage or failure.

3.6.2.5 Brake Structure Performance

3.6.2.5.1 Static Structural Torque Performance

The wheel and brake shall be capable of sustaining the minimum structural torque, specified in Table - 5 (Brake Performance Parameters) for a minimum of 3 seconds without failure of assemblies or components.

3.6.2.5.2 Brake Piston Stop Pressure Performance

With the heatsink removed the brake shall be capable of pressurization to 150% of maximum hydraulic operating pressure for a minimum of 5 minutes without failure or hydraulic fluid leakage.

3.6.2.6 Brake Serviceability Performance

3.6.2.6.1 Brake Service Life Performance

The brake shall be designed to maximize the number of landings per overhaul, consistent with the existing weight limitations (see 1.4 - Approval), beyond a minimum fleet average threshold of 700 landings per overhaul. This shall be an evaluation criterion for the procuring activity.

3.6.2.6.2 Brake Parking Performance

The brake shall not fail, or exceed limits for leakage, brake rolling drag, and running clearance, after holding maximum hydraulic operating pressure for at least one hour following a simulated normal energy landing stop and simulated taxi-in.

3.6.2.6.3 Maintainability Performance

Compliance with wheel and brake maintainability design requirements shall be demonstrated.

3.6.2.6.4 Field Service Performance

The wheel and brake shall be required to meet performance requirements on-aircraft, and demonstrate 700 landings per overhaul.. The supplier shall be responsible for simulating aircraft conditions in the qualification laboratory. Laboratory qualification is an abbreviated attempt to demonstrate compliance with on-aircraft performance requirements. The supplier shall be responsible for maintaining qualification vintage performance on all delivered production articles.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for Inspection

The supplier shall be responsible for the performance of all inspection requirements (examinations and tests) as specified in the performance specification. The supplier shall seek procurement activity approval for any test facility not owned and operated by the supplier that may be used to fulfill the inspection requirements of the performance specification.

4.1.1 Responsibility for Compliance

The inspection set forth in the performance specification shall become a part of the supplier's overall quality program. The absence of any inspection requirements in the performance specification shall not relieve the supplier of the responsibility for ensuring that all products or supplies submitted to the Government for acceptance comply with all requirements of the contract. Sampling inspection, as part of manufacturing operations, is an acceptable practice to ascertain conformance to requirements: however, this shall not authorize submission of known defective material, either indicated or actual, nor does it commit the Government to accept defective material.

The supplier shall submit with the proposal a Quality Control (QC) program plan established to maintain the same heatsink material consistency used to qualify the wheel and brake. The QC plan shall include the use of qualification data to baseline the full-scale performance of the heatsink and the establishment of control limits within specification limits. Any deviations from the QC program, manufacturing process or control limits shall be reported to the procurement activity before the material is accepted by the Government.

4.2 Classification of Inspections

Wheels and brakes covered by the performance specification shall be subjected to the following performance tests:

a. Qualification Testing
b. Acceptance Testing

4.3 General Qualification Test Requirements

4.3.1 Scope of Qualification Testing

A qualification test program shall include all inspections, tests, and analysis specified in the performance specification. If during the course of qualification testing, corrective action is required, the supplier and procuring activity shall re-evaluate the previously approved test data, test plans, and reports to ensure their continued validity. The corrective action, extent of required retest and test plan revisions shall be subject to approval of the procuring activity.

Qualification testing may focus on components of the wheel or the brake; however, no detailed part, sub-assembly, wheel assembly, or brake assembly, shall be qualified individually. Final qualification approval, determined only by the procuring activity, shall be awarded only to a wheel and associated brake assembly.

4.3.2 Qualification Test Samples

The qualification test samples shall be production configuration. All details and assemblies shall be prepared with production processes. Any planned deviations to the production configuration or processes that may be necessary to produce qualification test articles shall be noted at the time of Critical Design Review (CDR). All qualification tests shall include a statement of conformity to the production design and process.

Friction materials shall be manufactured using production processes and equipment without exception. The locations within the furnace of all qualification disks shall be documented throughout the manufacturing process.

Test wheel and brake assemblies shall be equipped with necessary inlet fittings and adapters, and with chromel-alumel thermocouple leads for measuring temperatures of critical portions of the wheel and brake.

The supplier shall keep qualification test samples intact until qualification test approval has been granted by the procuring activity. Disposition of the test samples shall be provided with qualification test report approval.

One complete qualification vintage wheel and brake assembly and one additional spare heatsink shall be quarantined for future research and quality control baseline purposes. The quarantined article serial numbers shall be recorded in the qualification report. Disposition of quarantined articles shall require procurement activity authorization.

4.3.3 Qualification Test Plan

The supplier shall prepare and submit a test plan document at CDR for procurement activity review and approval, and shall update the plan on a routine basis. The test plan document shall include the following:

a. A complete and detailed listing of all test procedures and the sequence in which each test shall occur.
b. A complete description of the data to be recorded, a description of the recording equipment, and a sample of similar test data previously recorded on a similar test. The description shall include data sampling rates and data conditioning plans.
c. A description of the equipment to be used in the test and how this equipment shall be assembled for testing.
d. A quality program plan.
e. A qualification schedule

4.3.4 Qualification Test Attendance

The option of witnessing all or part of qualification testing shall be extended to the procuring activity engineering personnel. Updates to the qualification schedule shall ensure that two weeks of advance notice is furnished to the procuring activity prior to the start of any qualification test.

4.3.5 Qualification Safety of Flight Tests

Qualification testing shall objectively be complete and approved before wheel and brake equipment is released for flight test. The following minimum level of successful testing shall be completed before the wheel or brake equipment or the wheel-brake assembly is considered safe to release for flight test:

a. Wheels:
   1. All static load tests
   2. Burst test
   3. 30% of required roll test

b. Brakes:
   1. 100 % of structural torque test
   2. 100% of static and dynamic torque tests
   3. 100% of thermal tests
   4. 100% of leakage tests
   5. 100% of required analysis
   6. 60% of endurance test

4.3.6 Qualification Procedures and Data

4.3.6.1 Qualification Procedures

During qualification testing the following procedures apply unless stated otherwise in the individual test description of this performance specification:

a. Cooling air during a test condition shall not be allowed. The supplier shall indicate in the qualification test procedures when cooling air between conditions is planned.

b. The roll direction of the brake shall be maintained throughout the life of the heatsink, including when it may be moved to another test station. If the heatsink stack is removed it shall be replaced with all disks in the same location and orientation.

c. During any testing where brake frame deflections are critical, such as structural and dynamic testing, the brake shall be oriented so that the load path and deflections simulate the aircraft application.

d. Any unusual event, such as vibration, fires, tire skids and component failures shall be documented and reported within 1 working day, even if the event is not included in the success criteria of the test that it occurred.

e. Qualification test failures shall be documented and reported within one working day of the event. Qualification failures shall be documented in a database that tracks the event and the corrective action and the status of the corrective action. The corrective action plan shall be approved by the procurement activity. The corrective action plan shall track the impact on the configuration, the test repeat, and the repeat of other completed tests affected by the configuration change.

f. Supplier requests for deviations to the requirements of this procurement specification shall be documented in a database that tracks the request and all supporting data for the deviation. Deviations shall be approved or rejected by the procurement activity. The database shall track the status of all deviation requests and it shall be submitted as an appendix to the qualification test report.

g. Qualification shall take place in a laboratory ambient conditions that comply with approved specification (Ref.: Test, Environmental).

h. All dynamic torque tests shall be conducted with tire at rated load. Pressures shall be adjusted as necessary to compensate for dynamometer roadwheel curvature.

4.3.6.2 Qualification Data

During qualification at least the following data shall be recorded in the qualification test report:

a. Weight and serial number for the wheel, brake, and tire used including test pressure.
b. Flywheel diameter, inertia equivalent, speeds and kinetic energies.
c. The test facility shall obtain time temperature relationships as applicable for the following components and present the data in the qualification test report:

    1. Hydraulic fluid closest to heatsink
    2. Wheel fuse plugs
    3. Tubewell clocked to worst case location
    4. Bead ledge clocked to worst case location
    5. Heatsink disks, as near as possible to the friction radius.
    6. Torque Tube under heatsink center

7. Axle at hottest location
8. Other critical components

Temperature recordings shall continue until peak temperature, unless cooling profiles are required. The supplier may propose deviations to the thermal data recording time at CDR.

d. Wheel load.
e. Brake hydraulic pressure (or force) for each stop.
f. Average and instantaneous dynamic torque for each stop.
g. Average and instantaneous friction coefficient (Mu) for each stop.
h. Average and instantaneous torque index for each stop.
i. Stopping time and distance for each stop.
j. Tangential force at the circumference of the tire required to rotate the wheel with brake pressure released to stated back-pressure after completion of every fifth stop.
k. Time required for wheel, brake, and tire assembly, landed against the flywheel, to stop the flywheel.
l. Brake piston running clearance prior to and after the test.
m. The thickness and weight of each disk prior to and after the test.
n. Time after stop to fuse plug release or partial release and energy level of stop (if applicable).
o. Ability of the tire and wheel assembly to retain nitrogen under braking conditions.
p. Conductivity readings for critical aluminum components and hardness of structural steel prior to and after testing.
q. Photographs of each heatsink disk wear surface prior to and after the test. Photographic resolution shall be high enough to characterize the surface texture of each wear surface. Additional photographs shall be included with 1:1 resolution to document and surface irregularities, such as grooving, plucking, pitting, cracking, etc.
r. Video with audio recordings of each test shall be provided in digital format recorded on compact disk. Audio recording fidelity shall be high enough to capture the full range of humanly audible brake noise.
s. Digital (tab delimitated) ASCII data files shall be archived and made available for each test. Sample rates shall be adjusted as necessary to rates sufficient to analyze brake vibrations. Strip charts printed directly from dynamometer should be made available for analysis.
t. Any other information that shall be of assistance to the ultimate users of the wheel and brake assembly.

4.3.7 Qualification Test Report

A Qualification test report shall be prepared for approval by the procuring activity approval. An interim progress report shall be published covering safety of flight tests and any other testing deemed necessary by the procuring activity. Regardless of any inherent virtue exhibited by the test results themselves, the first article test requirements shall not be satisfied until the procuring activity has approved the supplier's final qualification report. Any further production of equipment prior to such approval is undertaken at the supplier's own risk. The interim and final qualification report shall include the following for each test required by the procurement specification:

a. A statement of requirements.
b. A description of the test setup, instrumentation, and parameters. The description shall include certification of the test article configuration.
c. Complete coverage of all deviations, exceptions, failures, special approvals, and related items.
d. A statement of the test results.
e. Test data supporting the results. Data shall include both summary data and unfiltered data to permit evaluation. At the request of the procurement activity, the supplier shall make data

available digitally. It is the responsibility of the supplier to provide and store test data to the satisfaction of the procurement activity. Lost or incomplete test data shall constitute test failure, and retest shall be accomplished at supplier expense.

f. Test technician instructions and comments.
d. Certification of the accuracy of the recording instruments.

4.3.8 Special Test Requirements

The inclusion of any auxiliary feature in the wheel or brake design, such as a tire pressure control system or a brake temperature monitoring system shall require a formal demonstration and the procedure and results shall be approved in writing by the procuring activity

4.4 Wheel Qualification Testing

4.4.1 Wheel Pressure Test

4.4.1.1 Wheel Burst Test

The burst test load shall be applied to the wheel by means of hydrostatic pressure in the tire. Over-inflation valves may be removed or isolated for the burst test. Wheels shall be tested to the burst pressure 3.5 times the rated inflation pressure.

4.4.1.2 Wheel Over-Inflation Valve Test

The wheel and tire assembly shall be over-inflated until the over-inflation valve releases pressure. Inflation shall be at the maximum rate allowed by the valve stem and shall continue after the over-inflation valve releases until it is demonstrated that the valve releases pressure faster than inflation. Record the pressure at valve release and the rate of deflation. Document the size, weight and trajectory of debris ejected from the valve.

4.4.1.3 Wheel Static Pressure Retention Test

The tire and wheel assembly shall be inflated to a pressure of 1.5 times the rated inflation pressure specified in Table-3 (Wheel Performance Parameters) and completely immersed in water. The rate of leakage as evidenced by bubbles shall be recorded to demonstrate an acceptable leakage rate.

4.4.1.4 Wheel Pressure Diffusion Test

The wheel and tire assembly shall be subjected to pretest conditioning to ensure that the tire has grown and then stabilized at rated inflation pressure in compliance with approved specification (ref.: Tires, Aircraft Pneumatic). Record tire pressure and temperature at the beginning and end of a 24-hour period to demonstrate that the inflation pressure loss has not exceeded the requirement.

4.4.1.5 Wheel Dynamic Pressure Retention Test

The wheel and tire assembly shall be subjected to pretest conditioning to ensure that the tire has grown and then stabilized at rated inflation pressure in compliance with approved specification (ref.: Tires, Aircraft Pneumatic). Record tire pressure and temperature at the beginning and end of a 25 mile roll performed at the rated load of the wheel. Mileage accumulated during this test may be used in computing to total mileage in the roll test.

4.4.2 Wheel Static Test

Combined wheel loads shall be applied through a tire that is inflated to rated inflation pressure. Either nitrogen or water inflation may be used. If the tire is filled with water, the water shall be bled off during loading to approximate the same tire deflection that would result if nitrogen inflation were used, and the inflation pressure shall not exceed the pressure at maximum tire deflection. Yield loads shall be applied in both inboard and outboard directions on the same wheel and at the ground angle and magnitude. The wheel and tire assembly shall be mounted on an axle passing through the hub. The tire shall be loaded directly against a flat, nondeflecting surface. The loads shall be applied simultaneously, either continuously or in increments of approximately 10% of the specified values. Readings shall be taken at suitable points on the wheel to indicate deflections and permanent sets. The required combined load tests are specified below.

For the yield and ultimate combined load tests, it is permissible to limit the tire deflection to that deflection achieved under limit load conditions of vertical and lateral loads by use of load transfer blocks (saddle type) that bear directly on wheel rim structure. Another alternative is the use of tire inflation exceeding the aforementioned values.

4.4.2.1 Yield Combined Load Test

The wheel shall support the components of the yield combined load specified in Table – 3 (Wheel Performance Parameters), applied consecutively at 90°, 180°, and 270°, followed by two more load applications at the 0° position. Each load application shall be sustained for a minimum of 10 seconds. The 0° position shall be the most critical load contact point, which shall normally include the valve hole. The 90° increments may be altered when structural conditions dictate. The successive loading at the 0° position shall not cause permanent set increments of increasing magnitude. There shall be no yielding of the wheel resulting in loose bearing cups, nitrogen leakage through the wheel or past the wheel seal, or interference in any critical clearance areas. The wheel shall be tested with the brake installed, and it shall be determined that no interference exists. The bearing cups, cones, and rollers shall be used for this test.

4.4.2.2 Ultimate Combined Load Test

The ultimate combined load specified in Table – 3 (Wheel Performance Parameters) shall be applied at the 0° position of the same wheel on which the respective yield combined load tests were performed. The ultimate load shall be sustained for a minimum of 10 seconds after which there shall be no cracks in any area. The wheel shall be loaded in the most critical direction. The bearing cones may be replaced with conical bushings, but the cups shall be used.

4.4.3 Wheel Dynamic Test

4.4.3.1 Wheel Roll Test

The roll test shall consist of a continuous 25,000 mile roll of the wheel assembly against a rotating flywheel to complete the roll test spectrum of Table – 4 (Wheel Roll Spectrum). The supplier may propose for procurement activity approval to accelerate the roll test to a minimum roll distance of 5,000 miles by use of an appropriate K-factor selected to generate damages equivalent to 25,000 miles of service life. The wheel shall complete the roll test demonstrating compliance with the performance requirement.

4.4.3.1.1 Roll Test Criteria

Roll tests shall be performed with qualified tires approved by the procuring activity for aircraft usage. The wheel shall be mounted on its axle and positioned against a flat non-deflecting surface or flywheel. The wheel shall have the same angular orientation to the non-deflecting surface that it will have to a flat runway when it is mounted on an airplane and is under the wheel rated static load. During the roll test, the tire pressure shall not be less than 114% of the wheel rated inflation pressure. For side load conditions, the wheel shall be yawed to the angle that produces the appropriate side load component. Tires may be replaced as required, but replacement of wheel assembly parts shall not be allowed. Cooling air shall be allowed during roll testing for the purpose of extending tire life.

4.4.3.1.2 Thermal Conditioning

Prior to roll testing, all wheel and brake assemblies using shot peen, roll burnishing or other cold-working processes shall have been subjected to thermal conditioning equivalent to the cumulative temperature-time history resulting from brake heat dissipation experienced during normal and overload brake testing, as required in this specification. Thermal conditioning may be accomplished by performing normal and overload brake testing, by simulation of the thermal distribution in the wheel using a simulated brake heat sink to produce the same temperatures encountered during testing or by a suitable oven heat soak.

4.4.3.1.3 Stress Measurement

Prior to or during the roll testing, the stresses in the bead seat or other critical areas affected by the tire shall be measured on the roll test wheel or a separate wheel for each loading condition and for each test inflation pressure that is used.

4.4.3.2 Wheel Roll to Failure Test

After completion of the minimum roll requirement, the roll test conditions of Table – 4 (Wheel Roll Spectrum) shall be repeated until wheel failure occurs. Wheel failure shall demonstrate compliance with performance requirements. Tie bolt or bearing failure during this test shall not be construed as wheel failure.

With approval of the procuring activity, the roll to failure portion of this test may be concluded prior to failure provided that four times the required roll test distance has been obtained on the test wheel. The supplier shall submit analysis to substantiate benign wheel failure along with any request to conclude the test prior to failure. The test report shall be amended to include extended roll data.

4.4.3.3 Wheel Roll on Rim Test

The wheel assembly, without a tire, shall be rolled without failure at a speed no less than 10 mph at the wheel rated static load for a distance of 15,000 feet to demonstrate compliance with the requirement. The axle angular orientation with the load surface shall represent that of the airplane axle to the runway under the rated static load

4.5 Brake Qualification Testing

4.5.1 Brake Torque and Energy Test

4.5.1.1 Brake Static Torque Test

The supplier shall conduct an approved static torque series that determines peak static torque across the range of normal operating temperatures and hydraulic operating pressures, including maximum hydraulic operating pressure. Maximum hydraulic pressure for static torque testing ONLY shall be 750 psi. For each static torque condition, record actual peak torque, hydraulic pressure, all heatsink disk temperatures, ambient temperature and relative humidity. The approved complete static torque series shall be completed at intervals as specified in Table - 7 (Brake Endurance Cycle Sequence). Where necessary it is acceptable to conduct a service energy single-stop in order to heat the brake for hot-brake static torque testing. At the midpoint of the service cycle test sequence the static torque series shall be expanded to included the following wet-brake procedure:

a. Complete the static torque series.
b. Place the brake in a humidity chamber at 100% humidity and 100F for 24 hours.
c. Repeat the cold-brake portion of the static torque series within 2 hours of removal from the humidity chamber.

d. Conduct a series of 15-mph taxi stops until the bulk heatsink temperature reaches 300F then cool the brake to <150F. Record temperatures and number of taxi stops.
e. Repeat the cold-brake portion of the static torque series.
f. Continue with the dynamic torque test.

At maximum hydraulic operating pressure the brake shall demonstrate compliance with the static torque requirements of this specification.

4.5.1.2 Brake Torque Sensitivity Test

A new and a worn brake shall be subjected to test conditions that survey torque sensitivity by recording peak torque index across a wide range of operating conditions, simulating taxi and high speed braking. Braking shall be limited to (2) second snubs at each condition. The dynamometer inertia shall be set equivalent to that used for the partially worn RTO in order to minimize speed changes during each test condition. Test conditions shall include all combinations of the following conditions:

a. Target Pressures (psi) = 200, 300, 400, 625
b. Pressure Ramp Rate (psi/sec) = 115, 2150, 4170
c. Target Initial Temperature (°F) = 100, 300, 800
d. Velocity at rotors tight (mph) = 12, 23, 70, 104

For each test condition average and instantaneous torque index values shall be recorded along with associated test parameters. Instantaneous torque index shall be reported at peak torque for each snub. Average torque index and instantaneous peak torque index data shall be reported in tabular format and plotted to demonstrate compliance with torque index limits. Individual plots showing test snubs with associated instantaneous parameters shall be included in an appendix to the qualification report.

4.5.1.3 Brake Peak Dynamic Torque Test

The supplier shall propose a peak torque test that surveys the full range of brake operating conditions with a new and a worn brake. The test plan proposal shall be included as part of the deliverables for CDR. The test plan shall include periodic re-conditioning of the friction surfaces by way of service energy landings with hot and cold taxi stops. Testing may be conducted on a shaft dynamometer to capture peak torque that might exceed the skid potential on a smooth road wheel dynamometer with a tire installed. Testing shall include but not be limited to at least 5 velocity levels from taxi to RTO speeds, maximum hydraulic operating pressure and mid-range pressures, maximum pressure ramp rate of TBD psi/second, hot and cold braking, and both new and worn heatsink conditions. Upon completion of the primary survey, the test plan shall require a secondary survey that focuses at and very near conditions that produced the highest peak torque recorded in the primary survey. The secondary survey shall record at least 20 data points.

4.5.1.4 Brake Normal and Overload Test

The normal and overload test shall be completed as specified in Table - 6 (Normal and Overload Sequence). Normal and overload stops shall be performed in accordance with conditions specified in Table - 5 (Brake Performance Parameters). Completion of the test includes sequences of constant pressure series and static torque test as specified in the test table. Constant pressure series stops shall be conducted at normal energy conditions except hydraulic pressure shall be held constant and average deceleration is recorded for information purposes only.

Initial brake temperatures shall not exceed 150F. Forced air cooling between test conditions to achieve initial temperature is allowed, but shall not be used during any test condition. For each overload condition and preceding normal condition, temperatures shall be recorded without forced air-cooling until peak temperatures are achieved.

Components of the wheel and brake assembly shall not be changed. This includes, but is not limited to, heatsink components, hydraulic seals, wheel thermal fuses, wheel bearings, and etc. The tire may be replaced as necessary. When the wheel assembly is removed and reinstalled, and when the heatsink is evaluated, the brake rotating disks must be placed in the same position and in the relationship with the other disks that they were when the wheel was removed.

At the beginning of the test and after each overload stop, hardness and conductivity measurements shall be taken at critical wheel and brake structural locations. Heatsink disk thickness, weight and friction surface characterization photographs shall be documented concurrent with hardness and conductivity measurements. Each inspection shall include a hydraulic leak check and documentation of brake running clearance prior to disassembly. When the brake is reassembled, the qualification brake rolling drag test shall be performed before continuing on with the test.

After completion of the tests, all parts shall be cleaned and inspected for defects. Structural parts shall be inspected using aided inspection methods, such as magnetic particle or dye penetrant. Inspection documentation shall be included in the qualification report.

No parts shall have cracked during this test to the extent of compromising the structural integrity during the normal and overload stop conditions. If cracks or defects are present, an analysis shall be performed to determine the origin and cause of the defect and the potential effect of continued service. The analysis shall be included in the qualification test report. There shall be no cracks, chipping, or chunking in the rotor and stator drives of the heatsink.

When the brake has completed the normal and overload test, including post-test inspection, it shall be reassembled for follow-on RTO testing. All components, especially the heatsink disks, shall be reassembled in original positions and orientation.

4.5.1.5 Brake RTO Test

RTO testing shall be completed using mechanical inertia dynamometers. The brake shall bring the road wheel or inertial plates to a complete stop within the distance specified. RTO testing shall not result in a sustained fire with flames exceeding a height approximately equal to the top of the tire within 5 minutes of the RTO stop. When wheel thermal fuses release the wheel and brake shall be pressed down onto the dynamometer to simulate deflection of a deflating tire. Active cooling and fire extinguishing is allowed 5 minutes after the RTO stop or release of the wheel thermal fuses, whichever occurs last. Uncontrolled fires that risk laboratory safety shall be extinguished as the situation demands. Record temperatures until peak temperatures are confirmed for information purposes.

4.5.1.5.1 Partially-Worn Rejected Takeoff (RTO)

A Rejected Takeoff (RTO) test shall be performed in accordance with conditions specified in Table - 5 (Brake Performance Parameters). The RTO shall be conducted with the brake that completed the Normal and Overload Test.

4.5.1.5.2 Maximum-Worn Rejected Takeoff (RTO)

A Rejected Takeoff (RTO) test shall be performed in accordance with conditions specified in Table - 5 (Brake Performance Parameters) for information only. The RTO shall be conducted with a brake that has been machined to near worn limits. The brake shall be at 100% worn condition prior to the RTO stop. Testing shall follow the sequence outlined in Table – 8 (RTO

Sequence) using a road wheel dynamometer with a production wheel and tire. The test shall demonstrate the maximum energy that the brake can absorb. At the completion of the test the brake shall be evaluated to demonstrate that additional piston travel remains before contacting the piston stops.

4.5.1.5.3 Shaft Dynamometer Rejected Takeoff (RTO) Baseline

A Rejected Takeoff (RTO) test shall be performed with a brand new brake at test conditions specified for the maximum-worn RTO in Table - 5 (Brake Performance Parameters). Testing shall follow the sequence outlined in Table - 8 (RTO Sequence) using a shaft dynamometer, except no conditions are required after the RTO stop and kinetic energy shall be adjusted to duplicate net brake energy.

4.5.1.6 Brake Rolling Drag Test

The supplier shall conduct testing throughout the Normal and Overload test sequence to demonstrate compliance with brake rolling drag performance requirement with all adjusters operative. The one adjuster inoperable rolling drag performance requirement shall be demonstrated one time at the conclusion of the Normal and Overload test sequence. The supplier shall propose the brake rolling drag test procedure at CDR for procurement activity approval.

4.5.2 Brake Thermal Test

4.5.2.1 Brake Single-Stop Thermal Data Test

A series of single stops shall be performed with a new brake and repeated with a worn brake to provide data for thermal modeling. For each stop the initial heatsink temperature shall be equivalent to laboratory ambient. Conduct four single stops at 1, 2, 3, and 4 million foot pounds kinetic energy with a target deceleration of 6 ft/s^2. Continue to record temperatures until the heatsink temperature has cooled in still air to 100°F. After each stop, during cooling, a rectangular steel plate at least 4 feet per side shall be placed under the tire to simulate the ground.

4.5.2.2 Brake Maximum Fuse Plug No-Melt Test

A single stop test shall be performed with a new brake and repeated with a worn brake at kinetic energies that nearly result in released wheel thermal fuses. The test shall demonstrate that the wheel thermal fuse plug rating is correctly set to release before temperature limits specified for the wheel, brake, and surrounding structure are exceeded. The test shall be performed in a laboratory ambient still-air environment. A rectangular steel plate at least 4 feet per side shall be placed under the tire to simulate the ground. Immediately following the stop the wheel shall be positioned so that the thermal fuses are furthest from the 12 O'clock position. Consideration for thermal fuse tolerance and extrapolation of temperatures to impending fuse release shall be included in the verification of the correct fuse plug rating.

4.5.2.3 Brake Wheel-Fuse Plug Melt Test

A test shall be conducted to demonstrate that the wheel thermal fuse plugs release tire pressure at a rate that protects the wheel from catastrophic failure when it is exposed to temperatures above limits. This test may be performed in conjunction with another required high-energy brake test. The test shall account for, by test or by validated model analysis, extreme conditions, such as a maximum energy RTO with residual energy from a normal energy stop performed 1 hour prior to the RTO, where the wheel stresses and temperatures increase at the highest rates possible.

4.5.2.4 Brake Lining Fusion Test

A dynamic test shall be conducted to show that no lining fusion or welding will occur over the full operational range of the brake. The test procedure should be subject to approval of the procuring activity. (Not applicable to brakes having carbon-carbon heat sink materials.

4.5.3 Brake Stability Test

The supplier shall propose a test to demonstrate that all brake vibration modes are stable and do not exceed amplitude limits. Testing shall also validate dynamic modeling of the wheel and brake. The test shall record accelerometer data in addition to other key parameters during braking conditions. The proposed test conditions shall include new and worn brake wear-state and the full range of hydraulic pressure, pressure ramp rate, speed, and temperature. The test shall include simulation of boundary conditions at the flange-mount.

4.5.4 Brake Hydraulic Integrity Test

4.5.4.1 Brake Piston Housing Endurance Test

The hydraulic brake shall be subjected to 100,000 cycles of application and release of maximum hydraulic operating pressure. The test may be divided into four parts so that 25,000 cycles may be applied at four progressive wear stages approximating 25%, 50%, 75%, and 100% worn. The rate of cycling shall be no greater than 30 per minute. During and at conclusion of the test the static and dynamic leakage test shall be performed and parts shall be inspected to demonstrate compliance with the requirements of this specification. Alternate endurance tests may be used upon written authorization of the procuring activity.

4.5.4.2 Brake Piston Return Pressure Test

Tests shall be conducted before and after the endurance tests to verify the hydraulic pressures for piston to pressure plate contact and release, and for full retraction of the pistons to maximum running clearance. The tests shall be conducted with the brake mounted on a horizontal axle. When pressure is released, the test shall demonstrate compliance with the requirements of this specification.

4.5.4.3 Brake Piston Housing Extreme Temperature Test

4.5.4.3.1 Brake Piston Housing Aging and Heat Test

A brake, filled with hydraulic fluid, shall be subjected for 168 hours to a temperature of 250 +/-25°F. With the brake and hydraulic fluid being maintained at this temperature, the brake shall be cycled 1000 cycles at 50% of maximum hydraulic operating pressure followed immediately by 25 cycles at maximum hydraulic operating pressure. The brake shall demonstrate compliance with performance requirements.

4.5.4.3.2 Brake Piston Housing Cold Test

Upon completion of the aging and heat test, the brake, filled with operating fluid under atmospheric pressure, shall be subjected to a temperature of -65°F for a period of 72 hours. There shall be no leakage during this period. With the brake and operating fluid being maintained at this temperature, the brake shall be cycled 25 times at 50% of maximum hydraulic pressure followed immediately by 5 cycles at maximum operating pressure. The brake clearance shall be checked between each cycle to ensure that the pistons retract completely to the specified running clearance. The time required for the brake to release completely shall be noted. Upon completion of the cold test, the brake shall satisfactorily pass the static and dynamic leakage test.

4.5.4.4 Brake Leakage Test

Testing shall be performed on the brake that completed the Extreme Temperature Test. The brake shall be tested with hydraulic fluid for which the brake was designed.

4.5.4.4.1 Brake Piston Housing Static Leakage Test

The brake shall be parked for a period of 5 minutes with 150% of maximum hydraulic operating pressure applied. The brake shall then be parked for a period of 5 minutes with an applied pressure of 5 psig. The brake shall not exceed the specified brake leakage rate.

4.5.4.4.2 Brake Piston Housing Dynamic Leakage Test

The brake shall be subjected to 25 cycles of the application and release of maximum hydraulic operating pressure. The brake shall not exceed the specified brake leakage rate.

4.5.4.5 Brake Static Pressure Test

The brake shall be parked for a period of 5 minutes with 200% of maximum hydraulic operating pressure applied. The test shall be conducted with a heatsink that is fully worn. The brake shall not exceed the specified leakage rate and no part of the brake shall fail. Pressure shall then be increased until failure occurs and the ultimate pressure and failure location shall be recorded.

4.5.5 Brake Structure Test

4.5.5.1 Static Structural Torque Test

The brake shall be actuated at the maximum hydraulic operating pressure. Tangential load shall be applied at the static radius of the tire to achieve the minimum structural torque requirement specified in Table-5 (Brake Performance Parameters). The friction surfaces of the brake may be bonded together to prevent slippage during the test. The wheel and brake shall withstand the structural torque test without failure for 3 seconds. The structural torque test shall be conducted on a 100% worn brake.

4.5.5.2 Brake Piston Stop Pressure Test

The piston stops and brake housing shall demonstrate their ability to withstand pressurization of 150% of maximum hydraulic operating pressure for 5 minutes and demonstrate compliance with performance requirements. During the test the heatsink shall be removed so that all piston force is reacted at the piston stops.

4.5.6 Brake Endurance/Serviceability Test

4.5.6.1 Brake Endurance Test

A brake endurance test shall be completed per Table - 7 (Endurance Sequence). The test shall be successfully completed using one brake, without changing components until brake is fully worn. The brake shall be functional at the completion of the test. Wear measurements shall be taken periodically, at least every 10^{th} cycle, and included in the qualification report. Testing may be completed using a shaft dynamometer.

Forced air-cooling shall only be allowed between conditions to achieve a specified initial temperature. Transition time between conditions shall be minimal in order to maintain consistency. If the wheel or brake is removed for any reason, the heatsink friction surfaces shall not be disturbed and the components shall be reassembled in their exact original position and orientation. Any removals from the test stand or disruptions in the test lasting more than 24 hours shall be noted in the qualification report.

This test attempts to simulate generic service cycles and does not represent actual aircraft operations. The supplier shall be responsible for projecting in-service wear rate by using test data, T-38 aircraft operations information, and experience with other similar brakes in-service. The supplier may propose an alternative service cycle test to assist in in-service wear rate analysis.

4.5.6.2 Reserved

4.5.6.3 Maintainability Test

The supplier shall conduct a maintainability demonstration in accordance with this specification. The demonstration shall consist of a minimum of three disassembles and reassembles of the wheel assembly and brake assembly with the average time serving to determine compliance with maintainability performance requirements.

4.5.6.4 Field Service Test

The right is reserved to require suitable service tests of wheels, brakes or wheel-brake assemblies prior to granting of first article approval. This test shall consist of a series of flight tests and taxi tests with the equipment installed on the aircraft for which it was designed.

4.6 Qualification Analysis

4.6.1 Vibration Analysis

A dynamic model of the wheel and brake that accounts for all boundary conditions and operating conditions shall be prepared and demonstrated at CDR. The model shall identify vibration modes and stability margins. The analysis shall be updated as necessary during qualification testing in order to correlate with empirical data. When correlation is achieved the model shall again be demonstrated as a qualification deliverable. The model shall be maintained throughout the life of the program to support in-service problems that may develop.

4.6.2 Tolerance Analysis

A complete tolerance analysis shall be prepared and delivered for approval at CDR. The analysis shall include interface with the aircraft and clearance within the wheel and brake assemblies and installation. The analysis shall account for axle deflections across the range of loading conditions. The analysis shall account for all stages of heatsink wear, with attention to clearance between stationary and rotating disks. The analysis shall show conclusively, under all possible uneven wear patterns, that stationary and rotating disk wear grooving or ridges shall not contact each other in a manner that might destabilize or damage the brake, including the initiation of rotor cycloidal vibration.

4.6.3 Wear Rate Analysis and Declaration of Compliance

A wear rate analysis shall be completed that substantiates a brake wear-life guaranty. The analysis shall be included in the qualification report. The analysis shall take into consideration test data and supplier-requested information about aircraft operations. It is the responsibility of the supplier to conduct any additional testing and seek operational data that may be required to substantiate a wear-life guarantee. The analysis shall account for the fact that in normal service there are variations in brake usage, caused by different operating environments and pilot techniques. That is, the analysis shall apply brake wear-life variation consistent with that experienced in the commercial aircraft environment, using similar friction material. The analysis shall also account for the fact that brakes shall become contaminated to a degree consistent with that experienced in the commercial aircraft environment. A preliminary wear rate analysis shall be provided at CDR.

The final analysis shall be approved by the procuring activity and provided as a part of the qualification test report.

4.6.4 Stress Analysis

The supplier shall prepare a stress analysis for all critical fatigue and static loads on the wheel and brake. Analysis shall be accomplished by either analytical modeling or test strain methods and shall be verified by test strain data were possible. All static and fatigue loads shall be analyzed and margins of safety noted for critical parts. A preliminary stress analysis shall be provided at CDR. The final analysis shall be approved by the procuring activity and provided as a part of the qualification test report.

4.6.5 Thermal Analysis

The supplier shall prepare a complete thermal analysis on wheel, brake and interface components to predict whether the temperature constraints of the performance specification shall be met. A preliminary thermal analysis shall be provided at CDR. Analysis shall be approved by the procuring activity and provided as a part of the qualification test report

The preliminary analysis provided at CDR shall include a dimensional analysis proving that adequate clearance is available for all parts having relative motion at both temperature extremes under the most adverse dimensional combinations. This analysis shall be prepared so as to satisfy the adverse tolerance conditions and required test fluid.

4.7 Acceptance Testing

Acceptance tests shall consist of (a) tests of materials and parts, (b) tests of wheel assemblies, and (c) tests of brake assemblies. The acceptance test plan shall be provided at CDR.

4.7.1 Responsibility

Acceptance tests shall be the responsibility of the supplier. Prior to delivery of all equipment, the supplier shall subject the equipment submitted for acceptance under this contract to the inspections and tests performed in accordance with supplier prepared test procedures as approved by the procuring activity. A test shall be included to test each individual self-adjuster to the supplier's established quality control limits to ensure trouble-free operational service usage.

4.7.2 Acceptance Test Procedures

Acceptance tests shall be performed to verify that equipment supplied under the contract meets some of the critical requirements specified in Section 3, and is equivalent to qualification test equipment with respect to those critical requirements. Qualification test articles shall be subjected to acceptance test procedures before testing. Acceptance or approval of material during the course of manufacture shall not be construed as a guarantee of its acceptance in the finished product. All equipment shall have satisfactorily passed the applicable acceptance tests prior to delivery. No deliverable equipment shall have accrued more than 6 percent of its operating life (including all test and checkout time) when received by the procuring activity. If, during testing, 6 percent of the useful life of a limited life item is exceeded (based on the previously established replacement schedule), those items must be replaced prior to shipment to the procuring activity, and a final functional performance check shall be satisfactorily completed. Evidence of non-compliance with the above shall constitute cause for rejection. For non-complying equipment already accepted, it shall be the obligation of the supplier to designate the necessary corrections and incorporate them after approval by the procuring activity.

4.7.3 Tests of Materials and Parts

Materials and parts used in the manufacture of wheels and brakes shall be subjected to the following tests.

4.7.3.1 Examination of Product

Conduct examination of components to determine conformance to the performance specification with respect to material, workmanship, finish, dimensions, construction, surface conditions, and marking.

4.7.3.2 Material and Process Test

4.7.3.2.1 X-ray Control

Castings shall be classified and inspected radiographically in compliance with approved specification (ref.: Inspection, Casting).

4.7.3.2.2 Penetrant Inspection

Unless otherwise authorized by the procuring activity, penetrant inspection shall be in compliance with approved specification (ref.: Inspection, Penetrant). Fully machined aluminum castings shall have 100 percent penetrant inspection.

4.7.3.2.3 Magnetic Inspection

All magnetizable highly stressed parts of wheels and brake assemblies shall be subjected to magnetic inspection in compliance with approved specification (ref.: Inspection, Magnetic). All ground chrome plated parts shall be fluorescent magnetic particle inspected.

4.7.3.2.4 Ultrasonic Inspection

Inspection shall be in accordance with the applicable material specification approved on the design proposal drawings. If ultrasonic inspection is performed either on the original forging billet or at an intermediate forming state, a final machined forging need not be ultrasonically inspected again. Ultrasonic inspection requirements for titanium and steel products shall be in compliance with approved specification (ref.: Inspection, Ultrasonic).

4.7.3.3 Tests for Wheel Assemblies

Tests of wheel assemblies shall consist of individual and sampling tests.

4.7.3.3.1 Individual Tests

Each completed wheel assembly shall be subjected to the examination of product and weighed. The actual weight of the wheel shall be recorded on the processing document and shipping package in indelible ink.

4.7.3.3.2 Sampling Tests

Wheels shall be selected at random and the rim profile shall be inspected for compliance with radial and lateral runout requirements.

4.7.3.4 Tests for Brake Assemblies

Each completed brake shall be subjected to the following individual tests:

4.7.3.4.1 Examination of Components

Each brake component shall be carefully examined to determine conformance to this specification with respect to material, workmanship, finish, dimensions, construction, surface conditions and marking. Each brake shall be weighed. The actual weight of the brake shall be recorded on the processing document and shipping package in indelible ink.

4.7.3.4.2 Functional and Leakage Test

Each completed brake submitted for acceptance shall be subjected to a functional test for which written approval of the procedure has been received from the procuring activity. The brake shall be tested with approved hydraulic fluid. Testing shall include static and dynamic leakage tests. Shims may be used to protect adjusters from over-extensions when hydraulic pressures exceed maximum hydraulic operating pressure. Following test of brake assemblies, inlet ports shall be sealed with machined aluminum threaded plugs with o-rings; plastic or stamped shipping plugs shall not be accepted.

4.7.3.4.3 Friction Material Test Criteria

Periodic full-scale tests shall be accomplished in compliance with a procuring activity approved QC plan to test critical friction performance parameters.

For carbon brakes, the friction material test shall include the primary configuration carbon heat sink material consistency tests to assure uniformity in friction, wear, oxidation, density, strength, flexibility, and etc., compared to the material initially qualified. Representative samples from each manufacturing material lot or batch shall be submitted to tests similar to tests performed on the qualification material samples.

Similar supplier established material property tests shall be conducted on a steel heatsink, if this material is selected for the brake friction material.

4.7.4 Acceptance Test Failures

Should a failure occur during any of the acceptance or special tests specified herein, the following action shall be taken:

a. Immediately notify the procuring activity's representative and secure the failed article(s) away from production.
b. Prepare a malfunction report noting suspected cause and submit to procuring activity.
c. Determine the cause of failure.
d. Determine if the failure is a recurring manufacturing problem or design deficiency.
e. Submit analysis to the procuring activity.
f. Submit to the procuring activity for approval the proposed corrective action intended to reduce the possibility of the same failure(s) recurring.

When a failure occurs during the Acceptance Tests, the proposed corrective action shall include a test to check all equipment for the noted non-conformance until it has been determined that the defect has been satisfactorily corrected.

4.8 Similarity

Wherever adequate factual data exists that demonstrates similarity of design and requirements, this data may be utilized to minimize the test program. All claims of similarity shall be approved by the procurement activity.

4.9 Rejection and Retest

Equipment that has been rejected may be reworked or have parts replaced to correct the defects and be resubmitted for acceptance. Before resubmittal, full particulars concerning previous rejection and the action taken to correct the defects found in the original shall be furnished to the procuring activity for approval. After corrections have been made, all tests deemed necessary by the procuring activity shall be repeated.

When investigation of a test failure indicates that like defects exist or could exist in items already accepted, the supplier shall advise the procuring activity, designate the necessary corrective action(s), and incorporate them after approval by the procuring activity.

4.10 *Conformance to Test Samples*

Wheel and brake assemblies supplied under contract shall maintain qualification vintage performance.

Minor changes in drawings, parts, processes, or material may be made. Notice of such changes shall be submitted to the procuring activity for information. The right shall be reserved to disapprove any such changes that are considered to alter qualification vintage performance. The supplier shall assume all risks associated with change disapproval, including qualification test cost and replacement costs if necessary.

Major changes shall not be made without prior approval of the procuring activity.

5. PACKAGING

5.1 *Preservation and Packaging*

Preservation and packaging of wheel and brake assemblies shall be level A and C, as specified. Commercial packaging of wheel and brake assemblies shall be acceptable as approved by the procurement activity.

5.1.1 Level A

5.1.1.1 Wheel Assembly Packaging

Each wheel assembly shall be cleaned, preserved and packaged in compliance with approved specification (ref.: Packaging), using preservation compounds on all exposed metal surfaces susceptible to corrosive deterioration.

5.1.1.1.1 Bearing Preparation and Lubrication

All antifriction bearing parts and retainer parts that are not pressed into operating position prior to assembly shall be thoroughly cleaned and then packed to protect the item against corrosion in storage. The installed components shall be ready for operation without additional cleaning or greasing. Hub caps or grease retainers shall secure the cones assembled in place. The retaining components shall be free of all contamination and moisture. Each assembled bearing shall be covered on both sides by moisture impervious closures or seals. Whenever applicable, chemically inert, greaseproof barrier material conforming to approved specification (ref.: Barrier Material), Grade A, shall be used in direct contact with the bearing. Where both bearing hubs are joined in lieu of other interior closures or seals, the entire hub cavity may be fitted with cellulose wadding conforming to approved specification (ref.: Cellulose Wadding), wrapped or bagged within chemically inert greaseproof paper. The greaseproof side of the paper shall always be exposed to the grease.

5.1.1.1.2 Packaging of Wheel Assembly

The cleaning, preservation, greasing, assembly, and sealing of the bearings of the wheels shall be done in succession with a minimum of delay. The possibility of contamination of the wheel components shall be concluded during these operations. Where excessive motion of the cone might break the bearing seal, plywood or fiberboard shall be used to supplement blocking of the bearing seal. The blocking and hubcaps shall be securely attached to the wheel by any suitable mechanical means. Each preserved wheel shall be packed and sealed within a fiberboard container conforming to approved specification (ref.: Fiberboard Container). The container shall be sealed in accordance with the instructions in the appendix thereto. Processing documentation shall be shipped with the wheel.

5.1.1.2 Brake Assembly Packaging

Each brake assembly shall be cleaned, preserved and packaged in compliance with approved specification (ref.: Packaging), using preservative compounds on all external metal surfaces that are susceptible to corrosive deterioration. Preventive measures shall be instituted to preclude the preservative compounds from coming in contact with the braking surfaces. Each brake assembly shall be wrapped in chemically inert, greaseproof barrier material conforming to approved specification (ref.: Barrier Material), (or barrier material of equivalent protective value) and secured with pressure sensitive tape conforming to approved specification (ref.: Tape, Pressure Sensitive). The greaseproof side of the barrier material shall be exposed to the greased surfaces of the item. Each brake assembly shall then be unit packaged and sealed with a fiberboard container conforming to approved specification (ref.: Fiberboard Container). Processing documentation shall be shipped with the brake.

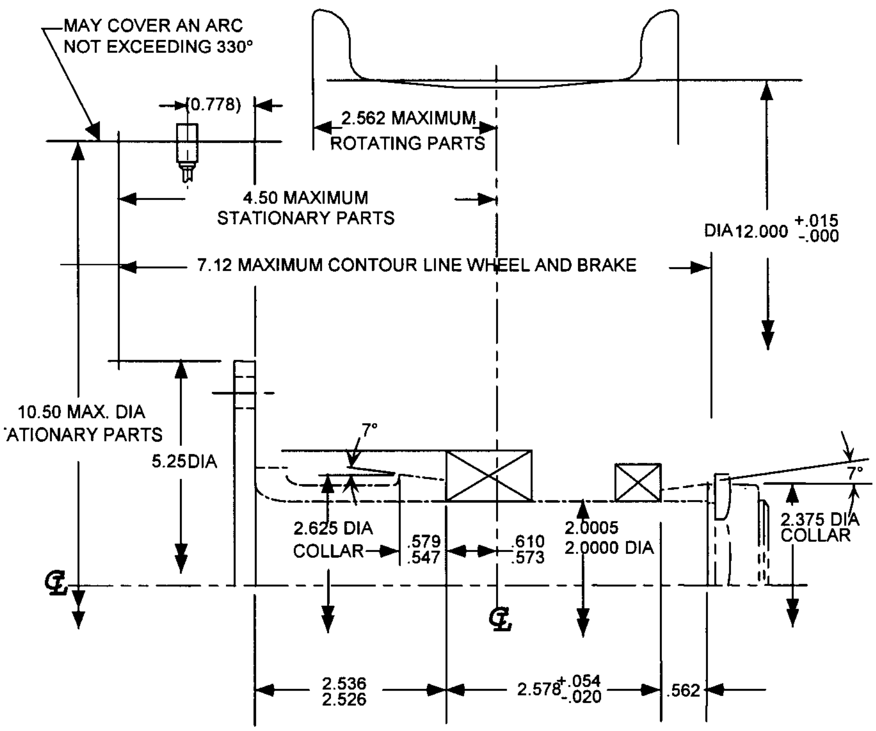
5.1.2 Level C

Preservation and packaging shall be such as to afford protection and prevent deterioration or damage, to a degree, which is adequate, but not in excess, during shipment under normal environmental conditions and commercial modes of transportation.

5.2 Marking

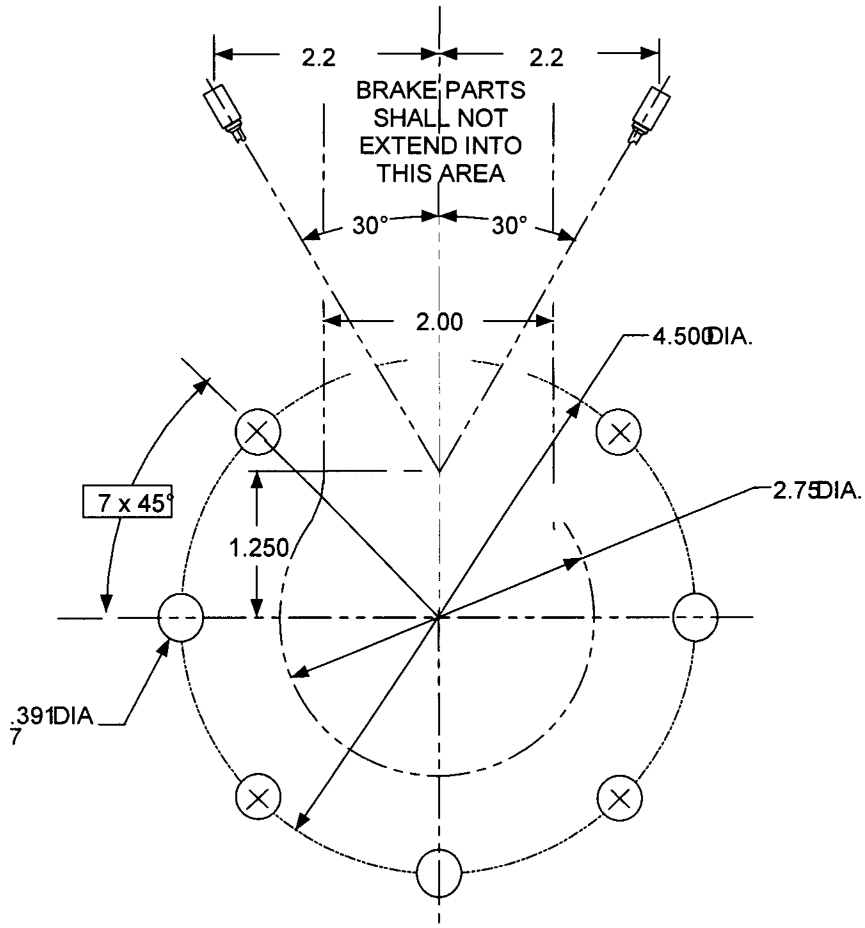
Interior packages and exterior shipping containers shall be marked in accordance with approved specification (ref.: Marking). Marking of unit and shipping containers shall include the date of manufacture and the actual weight of the assembly contained therein in pounds.

FIGURE – 1A
Wheel and Brake Envelope



UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ON: DECIMALS ANGLES
.XX ± .03 ± 0° 30'
.XXX ± .005.

FIGURE – 1B
Brake Flange Interface



UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES

TOLERANCES ON:	DECIMALS	ANGLES
	.XX ± .03	± 0° 30'
	.XXX ± .005	

FIGURE 2
Brake Friction Coefficient Limits

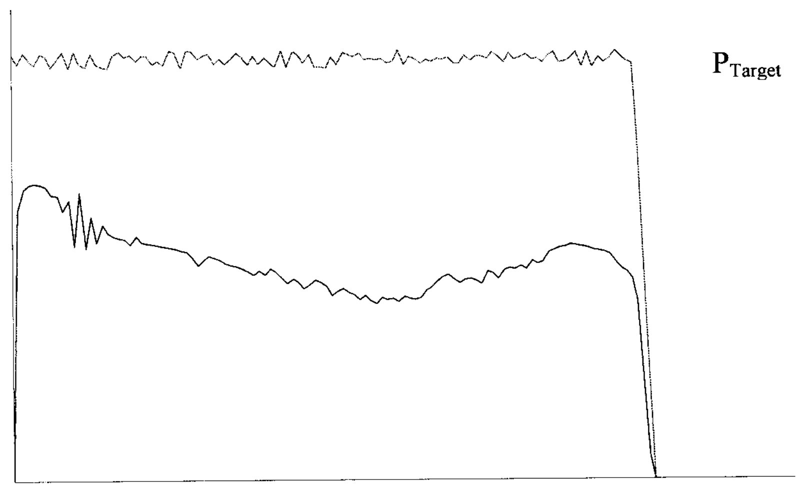
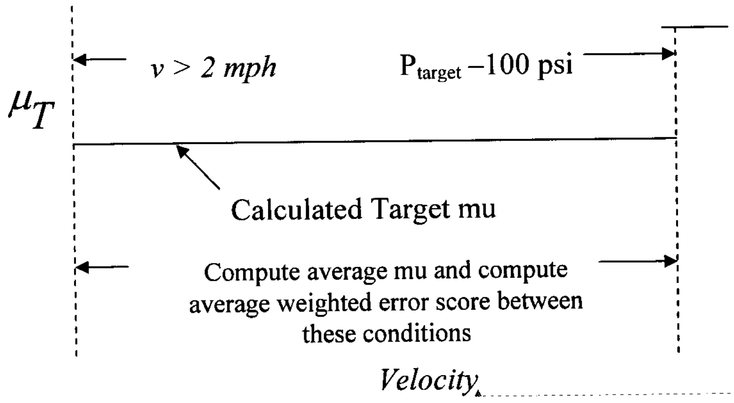


TABLE – 1
Specifications and Standards



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Supplier shall establish a target by averaging mu values from the time system pressure reaches target pressure minus 100 psi until dyno velocity reaches 2 mph. Minimum data sample rate for all calculations shall be 200 Hz.

Average weighted error score shall be computed using the same data set that was used to calculate the target mu, and shall be calculated as follows:

$$\Phi = \sqrt{\frac{\sum_{i=1}^{n}\left[W\cdot(\mu_M-\mu_T)^2\right]}{n}}*100$$

where:

μ_M	Instantaneous mu
μ_T	Target mu
W	Weighting function = $e^{(.916 * v/vi)}$
n	number of data points
v	Dynamometer velocity corresponding to μ_M
vi	Brakes-on dynamometer velocity

TABLE – 1
Specifications and Standards

Specification Subject	Active Specification
Anodize	MIL-A-8625
Barrier Material (Grease Proofed)	MIL-B-121
Bearing, Tapered Roller	FF-B-187
Bolt, Aircraft, 1200°F	NASM7874
Bolt, Aircraft, 160 KSI – 180 KSI	NASM7838
Bolt, Aircraft, 180 KSI – 200 KSI	NASM8831
Bolt, Aircraft, 60 KSI – 125 KSI	NASM6812
Boss, Port	MS33649
Casting, Permanent Mold	ASTM B108
Castings, Aluminum	SAE AMS-A-21180
Castings, Classification	SAE AMS-STD-2175
Cellulose Wading	A-A-1898
Coupling Assembly, Hydraulic	MIL-C-25427
Fiberboard Container	ASTM D5118 & D1974
Forging, Aluminum	SAE AMS-A-22771
Forging, Plate	MIL-T-9046
Forging, Steel	SAE AMS-F-7190
Forging, Titanium	MIL-F-83142
Fuse Plug, Thermal	SAE AS707
Gland Design, O-rings and other elastomeric seals	SAE-AS4716
Heat Treatment, Steel	SAE AMS-H-6875
Hydraulic Fluid, Petroleum	MIL-PRF-6083MIL-H-5606
Hydraulic Fluid, Synthetic	MIL-PRF-83282 & 87257,
Hydraulic Systems (ACFT Type I & II)	SAE AS5440
Inspection, Castings	SAE AS586
Inspection, Magnetic	ASTM E1444
Inspection, Penetrant	ASTM E1417
Inspection, Ultrasonic	MIL-STD-2154
Lubricant, Selection Guide	MIL-HDBK-275
Lubrication, Military Equipment	MIL-HDBK-838
Marking	MIL-STD-129
Metals, Dissimilar	MIL-STD-889
Packaging	MIL-STD-2073
Packing, Performed	MIL-G-5514
Paint, Colors	FED-STD-595
Passivation	ASTM A967
Plating, Cadmium-Electrodeposition	MIL-STD-870
Plating, Cadmium-Vacuum Deposited	MIL-C-8837
Plating, Chromium	AMS-QQ-C-320
Plating, Tin	ASTM B545
Plating, Zinc	ASTM B633
Pressure Relief Devices	SAE ARP1322
Protective Surface Treatments	MIL-STD-7179
Rubber, Elastomer	SAE-AMS-P-83485/1
Safety	MIL-STD-882
Seal, Wheel Static	SAE AS666

TABLE – 1
Specifications and Standards

Specification Subject	Active Specification
Shot Peen, Metals	SAE AMS-S-13165
Surface Texture	ANSI 1346.1
System, Brake (Design)	MIL-B-8584
Tape, Pressure Sensitive	ASTM D5486
Test, Environmental	MIL-STD-810
Threads, Controlled Root Radius	SAE AMS-S-8879
Tire and Rim Standard	Current Yearbook
Tires, Aircraft Pneumatic	MIL-PRF-5041
Valve, Filler	MS27436
Valve-Hydraulic Bleeder	MS27611
Washer	MS20002
Washer, Structural Fastener	AN960

TABLE – 2
Interface Drawings

Drawing Number	Drawing Title
3-40608	Piston, Landing Gear, Retractable - Main
7227217	
863147	20X4.4 14 Ply Radial Tire
56D1171	20X4.4 14 Ply Bias Tire
6U6033	Brake Master Cylinder

TABLE – 3
Wheel Performance Parameters

Parameter	Value	Unit
Wheel Rated Load	6,500	lbs
Rated Inflation Pressure (Unloaded)	265	psi
Combined Loads		
Radial-Yield	35,282	lbs
Side-Yield	12,380	lbs
Radial-Ultimate	46,020	lbs
Side-Ultimate	16,150	lbs
Minimum Burst Pressure	930	psi

TABLE – 4
Wheel Roll Spectrum

Load Condition	Distance (miles)	Radial (lbs.)	Side (lbs.)
Straight Roll ①	22,500	6,000	
Inboard Yaw	1,250	6,000	1,500
Outboard Yaw	1,250	6,000	1,500
Total =	25,000		

① 25 miles shall be done at reduced tie bolt torque at 90 percent of the minimum recommended on the design drawing.

TABLE – 5
Brake Performance Parameters

Parameter	Value	Unit
Static Torque Testing		
Minimum Static Torque at Full Brake Pressure	2000	ft-lbs
Minimum Structural Torque	5150	ft-lbs
Dynamic Torque Testing (gross kinetic energy)		
Service		
Kinetic Energy	2.14	ft-lbs x 10^6
Brake Application Speed	100	kts
Average Deceleration	6.0	ft/sec^2
Normal		
Kinetic Energy	3.60	ft-lbs x 10^6
Brake Application Speed	130	kts
Minimum Average Deceleration	10	ft/sec^2
Overload		
Kinetic Energy	4.25	ft-lbs x 10^6
Brake Application Speed	130	kts
Minimum Average Deceleration	10	ft/sec^2
Partially-Worn Rejected Takeoff (RTO)		
Kinetic Energy	8.71	ft-lbs x 10^6
Brake Application Speed	170	kts
Minimum Average Deceleration	6	ft/sec^2
Maximum- Worn Rejected Takeoff (RTO)		
Minimum Kinetic Energy	8.71	ft-lbs x 10^6
Brake Application Speed	170	kts
Brake Wear State	100% Worn	Wear Pin
Minimum Average Deceleration	6	Ft/sec^2
Brake Rolling Drag		
All Adjusters Functioning	30	Ft-lb
One Adjuster Inoperable	100	Ft-lb
Peak Dynamic Torque (Landing Gear Limit)	4000	Ft-lb

TABLE – 6
Normal & Overload Sequence

Sequence	Normal Stops	Overload Stops	Condition
1	6		Constant Pressure Series
2	17		Normal Energy Stop
3		1	Overload Energy Stop
4	16		Normal Energy Stop
5		1	Overload Energy Stop
6	17		Normal Energy Stop
7	6		Constant Pressure Series
8		1	Overload Energy Stop
9	16		Normal Energy Stop
10		1	Overload Energy Stop
11	17		Normal Energy Stop
12	6		Constant Pressure Series
13		1	Overload Energy Stop
TOTALS	100	5	

Constant Pressure Series

Stop	Pressure
1	100
2	200
3	300
4	400
5	500
6	625

TABLE - 7
Brake Endurance Cycle Sequence

Sequence	Description	Notes
1	Static Torque Series	• As proposed by supplier and approved by procurement activity
2	100 x Service Cycle Series	• I.E. = 4800 lbs. • Condition 12 Target K.E. = 2.14 MFP • Repeat series 100 times.
3	Static Torque Series	• As proposed by supplier and approved by procurement activity. • Conduct additional wet static torque testing as specified.
4	5 x Service Cycle Series	• I.E. = 4800 lbs. • Condition 12 Target K.E. = 3.6 MFP
5	Static Torque Series	• As proposed by supplier and approved by procurement activity
6	Repeat Sequences	• Repeat sequences until brake is fully worn.

Service Cycle Test Series

Cond.	Initial Speed (mph)	Taxi Distance (ft)	Final Speed (mph)	Target Decel (ft/s^2)	Notes
1	5	200	0	1	• Initial Temperature < 150F
2	5	200	0	1	[redacted]
3	10	1000	0	2	
4	10	2000	5	4	
5	20	3000	10	4	
6	15	2000	0	2	
7	15	4000	5	2	
8	10	1000	0	2	
9	15	1500	0	2	
10	5	1000	0	1	
11	5	200	0	1	
					•
12	138	See Note	0	6	• Landing Condition • Initial Temperature < 150F
13	30	1500	5	4	[redacted]
14	5	1000	0	2	
15	10	1500	0	2	
16	20	2500	10	2	
17	20	4000	0	4	
18	10	1500	0	2	
19	15	1000	5	2	
20	5	200	0	1	
21	5	200	0	1	

TABLE - 8
RTO Sequence

Sequence	Partially-Worn RTO	Maximum-Worn RTO	Shaft Dynamometer RTO
1	Normal & Overload Test	Break-in Series	Break-in Series
2	RTO Stop	Taxi Out	RTO Stop
3		Takeoff Roll	
4		RTO Stop	
5		Clear Runway	

Sequence Title	Detail Requirements
Break-in Series	1. 3 x (17mph)-cold taxi stops, initial heatsink temperature <150F 2. Normal Energy Stop 3. 3 x (17mph)- hot taxi stops **Repeat 10 times** The supplier may propose an alternative brake-in series
Taxi Out	Taxi 3 miles at 17 mph. Perform a taxi stop after each mile.
Takeoff Roll	Roll 7000 feet at 70% of RTO brake application speed.
RTO Stop	Perform stop per requirements specified in Table - 5 (Brake Performance Parameters).
Clear Runway	Taxi 1000 feet at 17 mph and perform taxi stop.